United States Military Academy
West Point, New York 10996

Optimal Deployment Measures Research for Networked Sensor Technologies as part of the Future Combat System

A Research Project Presented to:

The Army Research Laboratory

&

The Departments of Systems Engineering & Mathematical Sciences, United States Military Academy

By
Major Michelle M. McCassey, Ordnance Corps
Analyst, Operations Research Center

Supervised by
Lieutenant Colonel (P) Mark J. Davis
Director, Operations Research Center (ORCEN), Department of Systems Engineering

Approved by
Colonel Michael L. Mc Ginnis, Ph.D.
Professor and Head, Department of Systems Engineering

A TECHNICAL REPORT
OF THE
OPERATIONS RESEARCH CENTER
UNITED STATES MILITARY ACADEMY

JULY 2001

The Operations Research Center is supported by the Assistant Secretary of the Army (Financial Management & Comptroller)

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*	2. REPORT TYPE	3. DATES COVERED *(From - To)*
July 2001	Technical	7/1/00 to 6/30/01

4. TITLE AND SUBTITLE
Optimal Deployment Measures Research for Networked Sensor Technologies as part of the Future Combat Systsm

5a. CONTRACT NUMBER
n/a

5b. GRANT NUMBER
n/a

5c. PROGRAM ELEMENT NUMBER
n/a

6. AUTHOR(S)
Major Michelle M. McCassey
Lieutenant Colonel Mark J. Davis

5d. PROJECT NUMBER
n/a

5e. TASK NUMBER
n/a

5f. WORK UNIT NUMBER
n/a

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Operations Research Center of Excellence
Department of Systems Engineerig
United States Military Academy
West Point, New York 10996

8. PERFORMING ORGANIZATION REPORT NUMBER
n/a

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Army Research Laboratory

10. SPONSOR/MONITOR'S ACRONYM(S)
ARL

11. SPONSOR/MONITOR'S REPORT NUMBER(S)
n/a

12. DISTRIBUTION/AVAILABILITY STATEMENT
Distribution Statement A - Approved for Public Release; Distribution is Unlimited

13. SUPPLEMENTARY NOTES
n/a

14. ABSTRACT
In response to the changing operational environment facing the nation and the Army during the 21st Century, the Chief of Staff and Secretary of the Army announced a new Army Vision in October 1999 to build a land-power force capable of strategic dominance across the full spectrum of operations. The Vision establishes an explicit requirement for the Army to become more strategically responsive. The Army will implement the Vision by means of a three-stage transformation campaign over the next 10-20 years, leading to the establishment of an Objective Force that will incorporate revolutionary improvements in capability over the current force. The Army Transformation Campaign Plan represents the most challenging and significant effort to change the Army in a century. The IBCT represents the vanguard of that future force.

15. SUBJECT TERMS
Networked Sensors

16. SECURITY CLASSIFICATION OF: a. REPORT	b. ABSTRACT	c. THIS PAGE	17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON / 19b. TELEPHONE NUMBER *(Include area code)*
n/a	n/a	n/a	SAR	60	Major Mickie McCassey / 845-938-4383

ABSTRACT

In response to the changing operational environment facing the nation and the Army during the 21st Century, the Chief of Staff and Secretary of the Army announced a new Army Vision in October 1999 to build a land-power force capable of strategic dominance across the full spectrum of operations. The Vision establishes an explicit requirement for the Army to become more strategically responsive. The Army will implement the Vision by means of a three-stage transformation campaign over the next 10-20 years, leading to the establishment of an Objective Force that will incorporate revolutionary improvements in capability over the current force. The Army Transformation Campaign Plan represents the most challenging and significant effort to change the Army in a century. The IBCT represents the vanguard of that future force.

A future notional system is envisioned of remotely or manually deployed sensors that self-organize into a fused information source. If microsensing is successful, we will hopefully be able to replace landmines by arrays of acoustic, IR and other small sensors. The hope is that sensors will improve situational awareness, decrease response time, and increase the transparency of the battlefield to allow the ground component commander to make more informed decisions and employ weapons and systems more precisely.

This paper uses a systems engineering framework to understand and define a given problem. Through extensive literature research, it then addresses the variety of deployment platforms available and planned along with the latest versions of the IBCT and the RSTA Squadron who will potentially deploy these networked sensors. Finally, the foundation for an optimization model framework is explained, highlighting many of the issues surrounding the emplacement of networked sensors.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1 INTRODUCTION

1.1 MOTIVATION

The United States Army's Transformation Initiative, as introduced by the Chief of Staff of the Army General Eric K. Shinseki during the 1999 AUSA Conference, is unique in military history on numerous points. It is clearly unique in its size and scope. No other military in history has ever transformed itself following a dramatic and overwhelming victory, in this case, Operation Desert Storm. Additionally, never in American Military history have we ever attempted to transform ourselves during peacetime. On the contrary, normally we shun transformation efforts during peacetime, only to dramatically embrace them during actual conflict. (Shinseki 1999)

Command and control, surveillance and reconnaissance capabilities are keys to success of any mission. Warrior Extended Battlefield Sensors (WEBS) program attempts to enhance the U.S. Army capabilities for covering Beyond Line of Sight (BLOS) areas. Its purpose is to provide data to develop the Intelligence Preparation of the Battlefield (IPB).

A future notional system is envisioned of remotely or manually deployed sensors that self-organize into a fused information source. If microsensing is successful, we will hopefully be able to replace landmines by arrays of acoustic, IR and other small sensors. The hope is that sensors will improve situational awareness, decrease response time, and increase the transparency of the battlefield to allow the ground component commander to make more informed decisions and employ weapons and systems more precisely.

The Army's transformation places extraordinary demands on sensor technology. The ultimate intended impact of distributed networked sensors is inexpensive and persistent remote surveillance. (Army Research Laboratory 1999) It is hoped that current and future research will contribute greatly to the future combat systems. The intent is for distributed sensors to fill the situational awareness gaps, which ultimately complements global surveillance.

1.2 RESEARCH OBJECTIVES

West Point's participation is to develop an understanding of the optimal methods to deploy WEBS on the battlefield. It is intended to identify the methods and mechanisms that the Army will use to distribute and deploy WEBS type sensors. Emphasis will be placed on relevance to the Objective Force, Future Combat System (FCS) and Anti-personnel Landmine Alternative Program (APLA).

This technical report researched two aspects of WEBS deployment; 1) quantifying the "how" – by which platform should a sensor network be deployed and 2) quantifying the "who" – which element of the proposed IBCT should receive the sensor network deployment mission. Additionally, a framework for a potential optimization model to select the "how" and "who" identifies many of the concerns for deployment of any networked sensor system.

1.3 STAKEHOLDERS

The ultimate client for this research is the United States Army. The actual research clients for this project are the Sensors and Electronic Directorate Division (SEDD) of the Army Research Lab (ARL), the Night Vision and Electronic Sensors Directorate (NVESD), and the United States Military Academy (USMA) Operations Research Center (ORCEN) for Excellence. Other interested parties include both academia and industry with interest in sensor technology and systems engineering.

1.4 PROBLEM DEFINITION

The focus of this research is to develop optimal deployment measures for distributed sensor networks as part of the Future Combat System (FCS). Warrior Extended Battlespace Sensors (WEBS) create or add to an Unattended Ground Sensor (UGS) network system. All planning considerations are based on the future capabilities and responsibilities of the RSTA Squadron of the Interim Brigade Combat Team. The

focus is on the role of networked sensors and their expected capabilities planned for future combat system configurations at approximately the 2008+ time frame.

1.5 ANALYTICAL SCOPE AND CONTEXT

Since the roll of sensors is still developing and expanding, the scope of their potential use is still undetermined. Most military models focus on a particular scenario or campaign. Recent school models, such as those used in the officer basic or advanced courses, concentrate on a "lessons-learned" from South West Asia approach or the current peacekeeping operations in Bosnia and Kosovo. Since sensor applications are intended for wide usage, one must consider the extremes of open and complex to urban terrain layouts for planning purposes. The other scope limitations should focus on small-scale contingencies (SSC) up to full scale multi-theater wars.

Since the focus of all current research is centered on the Army's transformation, the design of the IBCT should be kept in mind when designing sensor applications. This paper concentrated on the IBCT concept, particularly the role of the RSTA Squadron with respect to potential sensor applications.

CHAPTER 2 BACKGROUND

2.1 GENERAL

Unattended ground sensor technology has been a focus of research and development in the intelligence circles primarily since the Vietnam War era. A range or hand and air emplaced sensors were developed in the late 1960's to detect the presence of the enemy troops or vehicles and to send signals over radio links to monitors based on the ground or in aircraft. Over the last few years, technology advancements, coupled with an increased awareness and use of sensor technologies for remote reconnaissance collection on the battlefield, has greatly increased. The importance of remote battlefield collection increases under the Future Combat Force concept due to the changing military structure and mission, thus increasing the demand for remote sensor use and information.

Unattended ground sensors come in various sizes and forms, may contain one type or multiple types of sensor technologies, can be deployed by several means and reports information on or about many different types of targets. Their expected capabilities include being able to monitor, image, track, predict, fuse and report information on a real-time basis. (Army Research Laboratory 1999)

UGS perform multiple missions, such as situation awareness, in order to provide remote target detection, location and recognition. UGS are small, low cost, and robust, and expected to perform their deployment mission on the battlefield for extended periods of time. Elements such as terrain, weather, background noise, and time of day affect the optimal performance of an UGS network.

2.2 APL-A

Approximately five years ago, in May 1996, the United States began a search for Anti-Personnel Landmine Alternatives (APL-A). The 1997 Mine Ban Treaty, also known as the Ottawa Convention, comprehensively bans all antipersonnel mines. It also required

- destruction of stockpiled mines within four years,
- destruction of mines already in the ground within ten years,
- and urges extensive programs to assist the victims of landmines.

When introduced to the world in December 1997, the Ottawa Convention had 122 immediate country signatories. It was ratified into international law in March 1999.

To date, the United States has not been a cosigner of the Mine Ban Treaty. The United States has refused to ratify the Ottawa Convention maintaining that land mines are needed on the Korean peninsula to deter an invasion from North Korea. While pledging support for cleaning up the mines, former President Clinton previously set a 2003 deadline to stop using land mines outside the Korean peninsula. The Pentagon maintains it intends to phase out all land mines in Korea by 2006 if alternative weapons can be found.

Promising alternatives to land mines do indeed exist. However, none are likely to be a militarily effective as the weapons they would replace. Sensor technology is one solution to the land mine issue. Current ongoing research poses several options to today's existing landmine structure. The proposed alternative involving sensor technology is coupling small sensors in the ground with remote unmanned weapons. Once the sensors were triggered, the weapons could fire at targets in their vicinity. The following chapter outlines current sensor research and overviews existing sensor technologies, from both U.S. and foreign sources.

CHAPTER 3 BATTLESPACE SENSORS

3.1 GENERAL

Various types of battlespace sensors exist around the world and have been used for various missions especially since the Vietnam War. The following are just a sample of systems that are currently fielded, being enhanced, or are proposed technologies.

3.2 REMOTE SENSOR APPLICATIONS

Sensors provide an extended rage surveillance capability without the requirement to maintain a physical presence in the surveillance area. Through the use of relays to maintain line-of-sight communications connectivity between the sensors and the monitoring site, monitoring operations can be conducted a hundred miles or more if desired. This capability enables commanders a means to economically monitor activity in an area of interest, conserving the use of other reconnaissance and surveillance assets for other critical tasks. Below the key applications of remote sensors are addressed.

3.2.1 General Surveillance

Providing general surveillance of lines of communications, landing zones, assembly areas, objectives, and other named areas of interest (NAIs) is the key function of networked sensors. Information obtained from the sensors is used to develop the general enemy situation and support the scheme of maneuver through the detection of enemy activity near insertion points or other objectives.

3.2.2 Early Warning

The intent of placing sensors along likely avenues of approach to serve as early warning devices provides commanders with a valuable tool to make decisions from with reducing risks to soldiers. Sensor strings may be placed forward, on the flanks, or in the rear of friendly units to facilitate force protection. Implanting sensors as far forward of friendly positions as possible, exploits the extended range of the remote sensor network to provide maximum reaction time.

3.2.3 Target Detection, Classification, and Acquisition

Only well developed sensor networks can provide potential target acquisition capabilities to a command. Implanting sensors along key avenues of communications or NAIs, enable commanders to initiate targeting actions. The key limitation of sensors in this application is a "man-in-the-loop" (MITL) clause. As technology emerges, "smart" sensors are being developed which when properly programmed can detect enemy equipment from friendly equipment. The issue of personnel identification is still being currently researched.

3.3 WEBS

Sensor technology is just a piece of the decision support tools available to today's modern commanders and soldiers. The WEBS program addresses many of the relevant items to a commander that help form the Intelligence Preparation of the Battlefield. With continued research, WEBS will continue to be a key factor in all intelligence aspects of warfare. WEBS applications can be broken down into three main categories:

1. Targeting
2. Short range target location and identification
3. Deep/Remote Reconnaissance to aid targeting

Additional applications include but are not limited to:

- Security
- Early Warning, like trip wire technology
- Area Denial – Landmine Alternatives
- Rear area protection
- Situational Awareness
- Battlespace awareness to enhance mobility
- Military Operations in Urban Terrain (MOUT)
- Remote area monitoring

3.4 EXISTING FIELDED TECHNOLOGIES

In existence since the World War II era, sensor technology has been a primary focus for only the last ten years. The United States along with several of its allies, has conducted both individual and joint research efforts in sensor capabilities. Outlined below is a sampling of many of the existing systems.

3.4.1 U.S.

3.4.1.1 AN/PPS-5B Ground Surveillance Radar (GSR)

Ground Surveillance Radar is a pre-Vietnam era system. The GSR is a lightweight, man-portable, ground-to-ground surveillance radar set for use by units such as infantry and tank battalions. The radar is capable of detecting and locating moving personnel at ranges of 6 km and vehicles at ranges of 10 km, day or night under virtually all weather conditions. Obsolescence of spare parts and a changing work environment have created a desperate need for an improved radar system. Integration of this system and I-REMBASS is expected program by 2005. (Cheney 1998)

Figure 1: GSR (Defense Daily Network 2001)

3.4.1.2 Improved Remotely Monitored Battlefield Sensor System (IREMBASS)

IREMBASS is a downsized version of the originally fielded REMBASS. The history of the REMBASS system dates to the Vietnam War, when a system called Unattended Ground Sensor System (UGSS) was used to detect enemy troop movement. UGSS was the first generation of these types of sensors, followed by REMBASS fielding in 1982, to evolve to the current IREMBASS system.

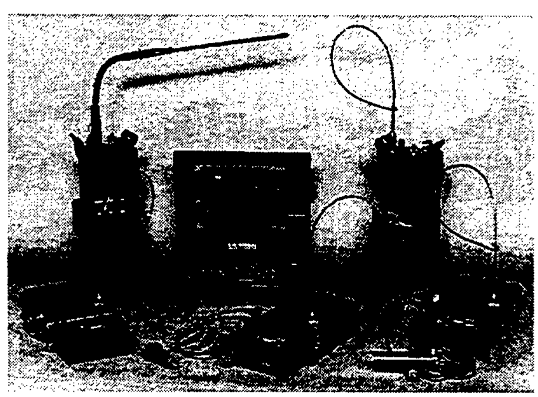


Figure 2: IREMBASS (Army Technology 1999)

The IREMBASS is an UGS system that detects, classifies, and determines direction of movement of personnel, wheeled vehicles, and tracked vehicles. It is designed to provide division and lower intelligence sections with information about activities in areas on or near the forward line of own troops (FLOT). Because of its flexibility, it provides world wide deployable, day/night, all-weather, early warning surveillance and target classification.

IREMBASS uses remotely monitored sensors hand-emplaced at likely avenues of approach. The sensors are normally in an idle mode with very low power dissipation. IREMBASS collects information using three sensors: seismic-acoustic, magnetic, and infrared-passive sensors. The seismic acoustic sensor is a classification sensor capable of detecting and classifying targets by ground vibrations and acoustic signals. This sensor classifies the target as personnel, vehicle, wheeled vehicle, track vehicles or unidentified. The magnetic sensor is a count indicator sensor capable of detecting, counting, and determining the direction of travel when objects containing ferrous metal (iron) come within its detection radius. The infrared-passive sensor is a count indicator sensor capable of detecting, counting, and determining the direction of travel of a target by measuring the temperature change of a target against a steady thermal background. (Commandant US Army Armor School 2000)

The information is incorporated in digital messages and transmitted through short burst transmission to the system sensor monitoring set. The system requires radio line of sight to transmit activations from the sensors to the monitor station. A radio repeater can extend the range by 15 km on the ground and by 100 km from the air. Units of the system can operate up to 90 days or longer without maintenance. (Federation of American Scientists 2000)

IREMBASS is fielded to the Special Operations Forces (SOF) for ground surveillance in deep penetration/denied area operations, in Low Intensity Conflict (LIC), and for surveillance of hostile activity behind enemy lines. It is also used in current counter-drug operations. Military Intelligence (MI) Battalions are also fielded with the systems.

3.4.1.3 AN/MLG-39 Ground Based Common Sensor Light (GBCS-L)

GBCS-L provides tactical commander with an organic capability to listen to, locate or jam opposition command and control and fire control nets. It is one of the ground components of the Intelligence and Electronic Warfare Common Sensor (IEWCS) system. GBSC-L provides a "smart jamming" capability against communications emitters.

Figure 3: GBCS-L (Federation of American Scientists 2000)

In late 1999, GBCS-L underwent a series of upgrades which evolved into the now Prophet system.

3.4.1.4 Prophet

Either mounted on a Heavy HMMWV, M1097, or dismounted as a man-packable capability, Prophet's primary mission is to provide 24-hour Force Protection (FP) to the maneuver brigade. Current plans call for six Prophet systems fielded to each division (two per Maneuver Brigade), four per ACR, three per BCT, two per SIB and five for Training and Doctrine Command (TRADOC). Prophet replaces the Trailblazer, Teammate, Trafficjam, and Manpack legacy systems. (PM Prophet 2000)

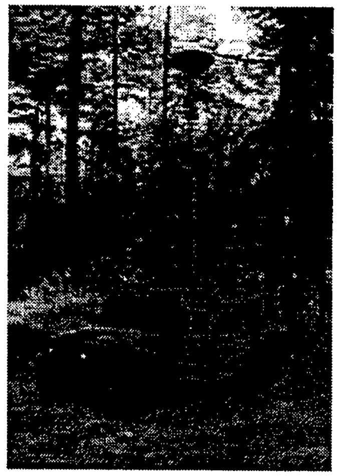


Figure 4: Prophet (Federation of American Scientists 2000)

3.4.1.5 Other secure wireless networks

Competition in today's wireless network environment has created several companies who rely on secure wireless networks. Many communications companies were forced to join the wireless network race or be run out of business. Security of communications lines is probably the greatest concern for the signal community. As the technology of wireless networks advances, military sources will be able to procure commercial-off-the-shelf (COTS) models which will greatly reduce to acquisition costs.

3.4.2 Foreign

Various USG have been designed and deployed by NATO countries. A need exists to standardize the mission of UGS among the NATO partners to ensure interoperability of information and components.

3.4.2.1 Canada – Guardian

Work is ongoing on a sniper location system called Guardian. It was designed as an area-monitoring device to equip observation posts for perimeter defense. The system

uses acoustic sensors to detect sniper fire, and estimates the azimuth and elevation of the enemy shooter.

3.4.2.2 United Kingdom – Halo

HALO is a British fielded system used to monitor artillery fire. A few unattended acoustic and met sensors are deployed for long-range detection of a transient signal emanating from artillery fire. Bearing information is extracted from the various UGS and transmitted to estimate source location.

3.4.2.3 Germany – BSA

A system named BSA was developed with detection, classification, and type identification of personnel and ground vehicles capabilities. In hopes of improving probabilities of detection and classification, work is ongoing to combine networks of seismic and magnetic, IR, and pyrotechnic-electric sensors.

3.4.2.4 Denmark

Acoustic and seismic UGS are deployed to estimate ground vehicle movement and locate explosion events.

3.4.2.5 France

Various mature systems have been developed especially for sniper detection. Select combinations of sensors, primarily acoustic, IR, and lasers, are integrated to detect and estimate azimuth and elevation of detected snipers. Additionally, work is ongoing to develop UGS for ground vehicle detection.

3.5 CURRENT SENSOR RESEARCH EFFORTS

Sensor technology is ever changing, just like any emerging system such as the computer. The next section discusses the different types of sensors currently being researched. Appendix C outlines the specifications for the different types of sensors.

3.5.1 Electro-optic

Visible or optic sensors are considered a good tool for daytime and clear weather conditions. They afford a familiar view of an area of terrain but can be deceived by employment of camouflage and concealment techniques. They offer images that can not be achieved by other sensor systems or in thermal images and radar depictions. Their most notable disadvantages are that they are restricted by weather conditions and that they are limited to daytime use only.

3.5.2 Acoustic

Acoustic sensors are the most common non-imaging sensors. They provide non-line of sight detection and classification capabilities for a number of enemy battlefield targets at significant ranges. They provide early detection of many targets and generally detect targets operating below the 150 Hz range. (Hopkins 2000) The maximum effective range is 50 meters for personnel, 250 meters for wheeled vehicles and 700 meters for track vehicles. The range of detection is 360 degrees. For all types of targets, the probability of detection is 0.95 and the probability of classification is 0.80. (Gerber 2001) Some terrain features and environmental factors affect the collection abilities of acoustic sensors.

3.5.3 Seismic

Seismic sensors are a low cost, non-line of sight sensor that provide unique detection capabilities in the case of adverse acoustic propagation conditions. They

generally detect targets below the 150 Hz range with a maximum effective range of 30 meters for personnel (if they are talking or making audible noises), 250 meters for wheel vehicles and 500 meters for track vehicles. The range of detection is 360 degrees. For all types of targets, the probabilities of detection and classification are both 0.80. (Gerber 2001) Some terrain features affect the collection abilities of seismic sensors.

3.5.4 Magnetic

The magnetic sensor is a low cost, non-line of sight sensor that provides early detection of many targets. This sensor offers a highly orthogonal sensing modality from acoustic and seismic sensors. (Hopkins 2000) The maximum effective range is 3 meters for personnel (provided the person is carrying a metallic object), 15 meters for wheel vehicles and 25 meters for track vehicles. The range of detection is 360 degrees. For all types of targets, the probability of detection is 0.90. It is not possible to classify a target type with a magnetic sensor. (Gerber 2001)

3.5.5 IR/Passive Sensor

IR/Passive sensors are currently under development, with a goal to create an effective, low cost sensor. The IR/Passive sensor is a line of sight sensor that will be triggered by one of the three low cost sensors (acoustic, seismic, magnetic) when it detects a target. This sensor is used to look at a target visually to verify the target. The maximum effective range is 20 meters for personnel, 50 meters for wheel vehicles and 50 meters for track vehicles. The range of detection is 40 degrees. The probability of detection is 0.95 for personnel, 0.98 for wheel vehicles and 0.99 for track vehicles.(Gerber 2001) Their most notable advantages are that they are very hard to jam, provide good resolution, and have night time imaging capability. On the downside, they are not effective during thermal crossover – 1 to 1.5 hours after sunrise or sunset. Also, bad weather currently degrades their quality significantly.

3.5.6 FLIR (Forward Looking Infra-Red) Sensor

FLIR sensors are currently under development with a goal to create an effective, low cost sensor. They are line of sight sensors that will be triggered once one of the three low cost sensors listed above detects a target. The FLIR sensor sends a visual image in order to verify the target. The maximum effective range is 800 meters for personnel, 1100 meters for wheel vehicles and 1100 meters for track vehicles. The range of detection is 15 degrees. For all three types of targets, the probability of detection is 0.90 and the probability of classification is 0.70.(Gerber 2001) Both terrain and environmental factors may reduce the collection capabilities of the FLIR type sensors.

3.6 DEVELOPING TECHNOLOGIES

3.6.1 Raptor

The Raptor Intelligent Combat Outpost detects, classifies, and engages heavy and light tracked and wheeled vehicles. It is hand emplaced or air delivered suite of munitions, sensors, communication system, and a control station that enables the commander to protect his battlespace. Raptor will be comprised of acoustic overwatch sensors, an artificial intelligence platform (the gateway), and a ground control station, and lethal or non-lethal munitions. The current munition of choice is the Advanced Hornet (Wide Area Munition), but future munitions used with Raptor may be designed to provide effects consistent with the situation and the commander's intent.

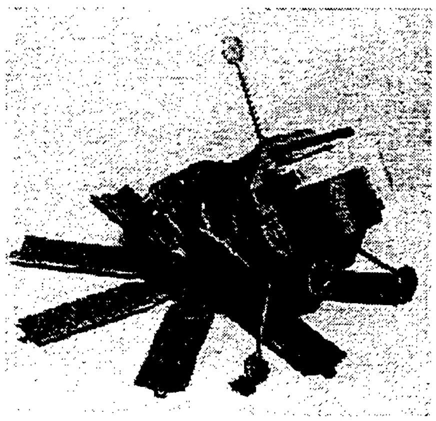


Figure 5: Raptor system (Federation of American Scientists 2000)

Prior to emplacement, each Raptor controlled munition is associated with a gateway. When activated by a manned ground control station, each munition is armed and the sensors are activated. When targets enter the field, each munition reports the range and bearing estimates of the two loudest targets to the gateway where a consolidated view of the entire target array is developed. This information is relayed periodically to the ground control station for display. When the control station operator determines the vehicles are hostile and should be engaged, he selects and sends to the gateway an engagement strategy. On receipt, the Raptor controlled munition field executes the attack command and will autonomously launch an attack against threat vehicles without further human intervention.

Fielding of the core Raptor system is planned for FY08. Fielding of the Ultimate Raptor system is expected in FY10. (JCF-AWE 1999)

3.6.2 ASTAMIDS

The ASTAMIDS system is a sensor package flown on a host platform. It is being designed to locate minefields and individual mines over a 2 square kilometer area. UAV, helicopter or powered parafoil is the intended means of deployment. Raw data would be sent to a ground control station for post-mission processing from a UAV or parafoil or be processed with an on-board system on a helicopter.

The tactical ASTAMIDS begins development in FY03 with production planned for FY08. Its supporting systems will be developed in parallel. Fielding is intended in FY10.

CHAPTER 4 THE "HOW" (PLATFORM) POTENTIALS

4.1 GENERAL

The purpose of this section is to introduce the sensor designers to many of the potential employment mechanisms, from as simple as hand emplaced to more sophisticated means such as unmanned aerial aircraft deployment. Concentration on the current Family of Scatterable Mines (FASCAM) was made since these sensors are expected to be part of the Anti-personnel Landmine Alternative Program (APLA). A spreadsheet detailing potential platforms' characteristics considered can be found in Appendix D.

Scatmine systems are remotely emplaced and laid without regard to a classical pattern. Aircraft, artillery, missile, or ground dispensers are the designed methods of delivery for close or remote emplacements. Because Scatmines are a very dynamic weapon system, great care must be taken to ensure that proper coordination is made with higher, adjacent, and subordinate units. They satisfy the high mobility requirements of modern warfare. Manpower, equipment, and tonnage are reduced for their emplacement. The current systems range from hand emplaced to aerial delivered.(Commandant US Army Engineer School 1998)

4.2 HAND EMPLACED

Foot patrols provide a clandestine means to implant sensors forward of friendly lines. The key limitations are the time, personnel required to establish the sensor network, and the weight of the sensors themselves. Unless a large number of patrols can be dedicated to implant operations, only a limited sensor network can be established in a short period of time. Foot patrols should be employed to emplace key sensor networks only when the terrain or threat precludes use of other implant methods. SOF or specially trained reconnaissance soldiers are the preferred agencies for these implant operations, however any unit with the capability to conduct ground patrols can carry out this mission. (Commandant US Marine Corps 1997)

4.2.1 MOPMS

The Modular Pack Mine System (MOPMS), a member of the FASCAM system, is a man-portable, approximately 165-pound, "suitcase" shaped mine dispenser that can be hand emplaced anytime before dispensing mines. The dispenser contains 21 mines (17 AT and 4 AP). Each dispenser contains seven tubes; three mines are located in each tube. The MOPMS provides a self-contained, on-call minefield emplacement capability for all forces.

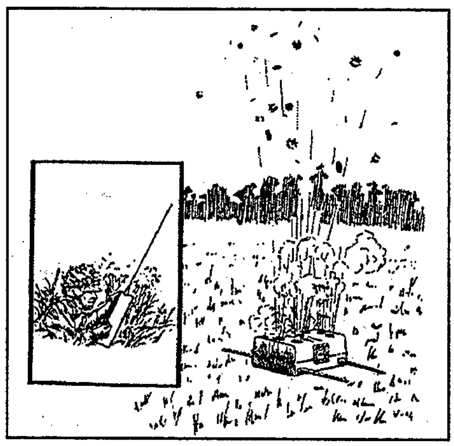


Figure 6: MOPMS (Commandant US Army Engineer School 1998)

Mines are dispensed on command using an M71 remote-control unit (RCU) or an electronic initiating device. The RCU can control up to 15 MOPMS containers or groups of MOPMS containers from a distance of 300 to 1,000 meters via separate pulse-coded frequencies. If the M71 RCU is unavailable, a direct wire link is used in conjunction with an M32, M34, or M57 blasting machine. The ability to command-detonate mines provides an added flexibility not currently available with other Scatmine systems.

When dispensed, an explosive propelling charge at the bottom of each tube expels mines through the container roof. Mines are propelled 35 meters from the container in a 180-degree semicircle. The mines have leaf springs along their outer circumference that are designed to push mines into proper orientation if the land on their side. The resulting density is 0.01 mine per square meter.

The MOPMS provides light and special forces with a versatile, compact system for emplacing nuisance minefields. Its main drawback is that the units can not be transported long distances by hand because of its weight.

4.2.2 Hornet

The Hornet, classified as a special purpose munition, is a man portable, 35 pound, cylindrical shaped system, that one person can carry and employ. The Hornet is a non-recoverable munition that is capable of destroying vehicles by using sound and motion detection methods. It employs acoustic and seismic sensors to automatically search, detect, recognize, and engage moving targets by using top attack at a standoff distance up to 100 meters from the munition. It compares gathered sounds with its internal database, which contains the characteristics of both friendly and enemy armored vehicles. If the database determines the sound matches an enemy armored vehicle, the device begins tracking it.

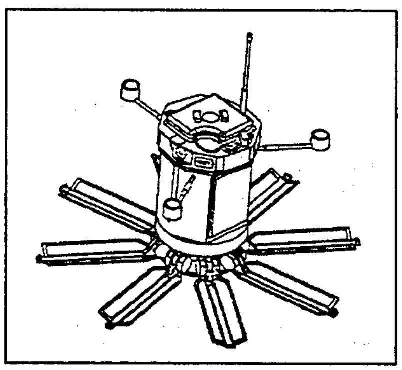


Figure 7: Hornet (Commandant US Army Engineer School 1998)

While tracking, the Hornet launches a 5-pound armament in the shape of a hockey puck referred to as an Explosively Formed Projectile (EFP) that contains munitions powerful enough to penetrate armor. Hornet can be manually armed or remotely armed using the same RCU as with the MOPMS system. The Hornet's active battery pack has an estimated life of four hours. Combat engineers, rangers, and SOF currently employ Hornets. (Tiboni 2001)

4.3 TUBE LAUNCHED

4.3.1 ADAM/RAAM

The Aerial-Denial Artillery Munitions (ADAMs) and Remote Anti-Armor Mines (RAAMs) systems, members of the FASCAM, were designed to provide a flexible, rapid-response mining capability. These systems provide the maneuver commander with the capability to emplace mines directly on top of, in front of, or behind enemy forces. Their responsiveness allows the mission to be executed quickly and allows the commander to effectively influence a rapidly changing battlefield. Since they are tube deployed, they allow the commander to emplace fields while maintaining maximum standoff from the target.

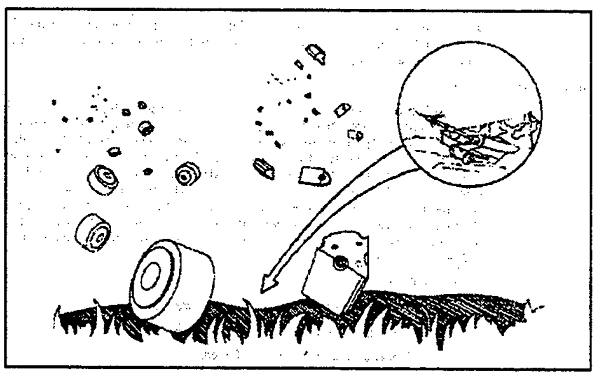


Figure 8: ADAM/RAAM (Commandant US Army Engineer School 1998)

A M109 A4/A5 155-millimeter howitzer delivers the ADAM and RAAM systems. The Self Propelled (SP) medium howitzers are highly mobile combat support which use M185 or M284 cannons. There are no special modifications or adaptations necessary for the firing system in order for the M109A4/A5 to fire the ADAM or RAAM projectiles. Mines are contained within a projectile and are dispensed while the projectile is in the air. The effective range for the M109 howitzer is 17,500 meters and for the M198 howitzer, 17,740 meters.

The two ADAM projectiles each deliver 36 AP mines. The M692 (long-duration) round contains M67 AP mines with 48-hour SD times. The M731 (short-duration) round contains M72 AP mines with 4-hour SD times. The RAAM projectiles also come in two different configurations each containing nine mines. The M741 (short-duration) round contains M70 AT mines with 4-hour SD times. The M718 (long-duration) round contains M73 AT mines with 48-hour SD times.

ADAM and RAAM missions are requested through normal artillery-support channels. Although the actual basic load numbers vary based on the unit and the mission, a representative basic load for an artillery battalion consists of approximately 32 ADAM and 24 RAAM (short SD times) rounds per artillery piece.

4.3.2 Javelin

Javelin is a portable antitank weapon with a carry-weight of 22.3 kg., supplied by Raytheon/Lockheed Martin. It is shoulder fired and can also be installed on tracked, wheeled or amphibious vehicles. The Javelin system consists of the Command Launch Unit (CLU) and the round. The CLU, with a carry weight of 6.4 kg, incorporates a passive target acquisition and fire control unit with an integrated day sight and a thermal imaging sight. The gunner's controls for the missile system are on the CLU.

Figure 9: Javelin (Army Technology 1999)

The round consists of the Javelin missile and the Alliant Techsystems Launch Tube Assembly. The range of the missile is 2500 meters. Javelin is a fire-and-forget

missile with lock-on before launch and automatic self-guidance. The propulsion is a two-stage solid propellant design that provides a minimum smoke soft launch.

The system is deployed and ready to fire in less than 30 seconds and the reload time is less than 20 seconds. The missile is mounted on the CLU and the gunner engages the target using the sight on the CLU, by placing a curser box over the image of the target. Unlike conventional wire guided, fiber-optic cable guided or laser beam riding missile, Javelin is autonomously guided to the target after launch, leaving the gunner free to reposition or reload immediately after launch.

A soft launch ejects the missile from the launch tube to give a low-recoil shoulder launch. The soft launch enables firing from inside buildings or covered positions. The missile is launched at an 18 degree elevation angle to reach a peak altitude of 150 meters in top attack mode and 50 meters in direct fire mode.

4.3.3 Battalion Mortar System (BMS)

The M121, 120mm Battalion Mortar System provides close-in and continuous indirect fire support to maneuver forces and can rapidly respond to the threat. This mortar system is being fielded to mechanical infantry and armored units. It is mounted in a M1064 Armored Personnel Carrier (APC), a member of the M113 family of vehicles. The M121 Mortar System consists of the following major components: M298 Cannon Assembly (110 lbs), M191 Bipod Assembly (70 lbs), M9 Baseplate (136 lbs) and the Carrier Adaptation Kit.

Figure 10: M121 Battalion Mortar System (Federation of American Scientists 2000)

With the use of an auxiliary M9 Baseplate and extension feet for the M191 Bipod, the M121 can be dismounted from the vehicle and emplaced for ground-mounted operations. Ammunition racks installed in the M1064 can accommodate 60 rounds of 120mm mortar ammunition.

The system's maximum and minimum ranges are 7200 meters and 200 meters respectively. Its maximum and sustained rates of fire are 16 rounds/min and 4 rounds per minute, respectively.

4.3.4 MLRS

The M270 Multiple Launch Rocket System (MLRS) or Self-Propelled, Loader/Launcher (SPLL) is made up of two major units and an electronic fire control system. It provides mobile long-range artillery rocket support for ground forces. The M993 Carrier Vehicle and the M269 Launcher-Loader Module (LLM) are the two major units that make up the MLRS. The MLRS has a cruising range of 300 miles at speed up to 40 miles per hour. The total MLRS weighs approximately 52,990 pounds.

Figure 11: MLRS (US Field Artillery School 1999)

4.4 GROUND VEHICLE LAUNCHED

4.4.1 Flipper

The M38 Flipper, a member of the FASCAM system, is a manual mine dispenser that is designed to emplace M74 AP and M75 AT mines. The Flipper provides the commander with great flexibility because it can be mounted on M113 armored personnel carriers (APCs), M548 cargo carriers, 2-ton trucks, and 5-ton trucks with no modification.

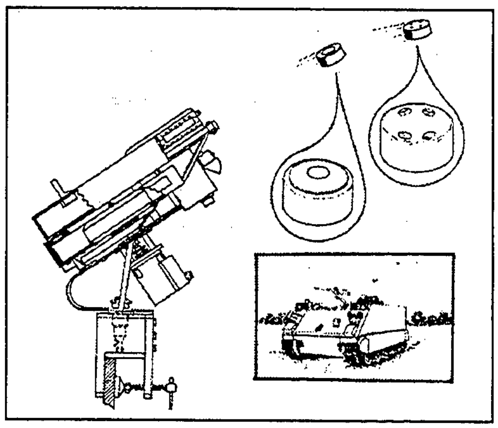


Figure 12: Flipper (Commandant US Army Engineer School 1998)

Flipper is a simple dispensing system and uses little automation to load and dispense mines. In short, mines are loaded by hand into a feeder chute. The operator determines the pattern by manually pivoting the dispenser across a 180-degree arc. Mines are dispensed in a 35-meter arc from the host vehicle. The operator can vary the field density, composition, and size, by adjusting the number of mines dispensed at each stopping point. For a standard minefield, the operator dispenses 10 M75 AT mines (two sleeves) at each dispensing point. In general, the fields have a front of 245 meters and a depth of 70 meters.

Flipper has two disadvantages – the emplacement method requires the crew to be exposed during operation and it is difficult for soldiers to dispense mines on the move.

However, when mounted on a tracked vehicle, The Flipper's mine-dispensing capability can keep up with maneuver forces during movement. An additional advantage is the system's versatility to emplace different field configurations with a greater accuracy on a point target or in restrictive terrain.

4.4.2 Unmanned Ground Vehicle (UGV)

UGVs augment the scouts, allowing them to "see" the enemy far beyond the range of current on board sensor systems. Currently there are several prototype programs being developed for potential tactical use. UGVs come in many shapes and sizes, depending on the type of intended mission. Many experiments help developers to gain insights on the effects UGVs have on scout platoon command and control, operational performance, Battlefield Operating Systems (BOS), and Tactics, Techniques, and Procedures (TTP). Preliminary insights demonstrate that the use of UGVs in a task force scout platoon significantly increases the survivability of Task Force and Brigade scouts. These technologies also provide a significant increase in situational awareness and reconnaissance effectiveness for the commander The integration of these technologies will require a thorough reevaluation of scout platoon doctrine.

Figure 13: UGV Prototypes ("Matilda" and "Sarge") (TRADOC 2000)

4.4.3 Ground Volcano

The Volcano is designed to emplace large minefields in depth. The Volcano multiple-delivery mine system, a member of the FASCAM, capable of sequentially

launching Gator type mines from launchers that can be transported helicopters or tracked and wheeled cargo carriers. Volcano was developed in the early to mid-1980s. The primary mission of the Volcano is to provide US forces with the capability to emplace large minefields rapidly under varied conditions. The system is vulnerable to direct and indirect fires, so it must be protected when close to the FLOT.

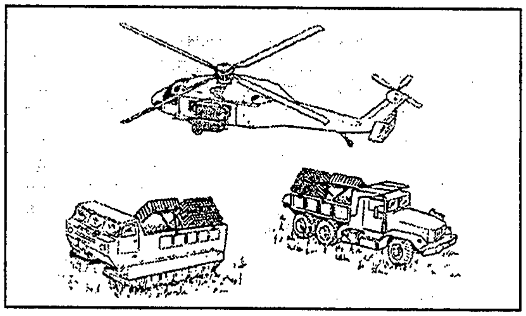


Figure 14: Volcano system (Commandant US Army Engineer School 1998)

For ground vehicle deployment, it can be mounted on any 5-ton truck, an M548 tracked cargo carrier, a heavy expanded mobility tactical truck (HEMTT), or a palletized load system (PLS) flat rack. The Volcano uses modified Gator mines and consists of four components – the M87 and M87 A1 mine canister, the M139 dispenser, the dispenser control unit (DCU) and the mounting hardware.

The Volcano uses M87 and M87A1 mine canisters. The M87 mine canister is prepackaged with five AT mines, one AP mine, and a propulsion device inside a tube housing. The M87A1 mine canister is prepackaged with six AT mines and no AP mines. Mines are electrically connected with a web that functions as a lateral dispersion device as the mines exit the canister. Spring fingers mounted on each mine prevent it from coming to rest on its edge. Reload time (not including movement time to the reload site) for an experienced four-man crew is approximately 20 to 25 minutes.

The M139 dispenser consists of an electronic DCU and four launcher racks. Four racks can be mounted on a vehicle and each rack can hold 40 M87-series mine canisters.

The racks provide the structural strength and the mechanical support required for launch. The racks also provide the electrical interface between the mine canisters and the DCU.

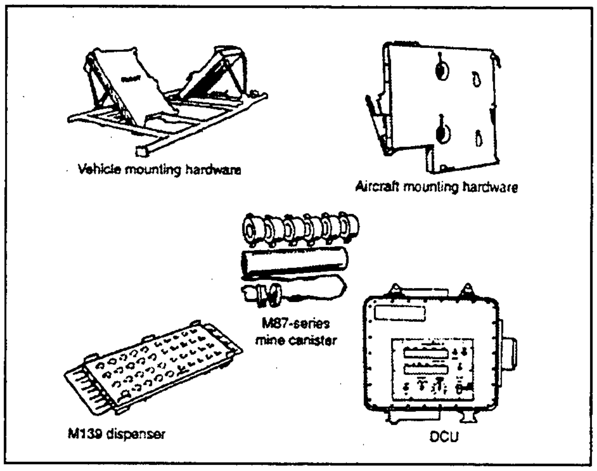


Figure 15: Volcano system components (Commandant US Army Engineer School 1998)

The operator uses the DCU to control the dispensing operation electrically from within the carrier vehicle. A counter on the DCU indicates the number of remaining canisters on each side of the carrier.

Mines are dispensed from their canisters by an explosive propelling charge. For ground vehicles, the mines are dispensed 25 to 60 meters from the vehicle at ground speeds of 8 to 90 kilometers per hour (kph). The average time to emplace one ground Volcano load (160 canisters or 960 mines) is 10 minutes. Both air and ground Volcano systems emplace a minefield with an average AT linear density of 0.72 mine per meter and an AP linear density of 0.14 mine per meter or a mined area approximately 1150 x 125 meters. These densities may vary slightly depending on deployment conditions. Volcano's responsiveness is limited only by the crew's ability to load the dispenser and the vehicle speed in traveling to and traversing the area to be mined.

Volcano training is currently being evaluated for upgraded training canisters. The current M88 and M89 training canisters do not fulfill the training requirements. The M88, which dispenses six inert miens, is too expensive and is a one-time use expending

approximately $48,000 per minefield. The M89 is an electronic canister that interfaces with the system but does not fire and is not useful to the air dispensed system. It is planned for the new training canister will be reloadable for multiple uses and provide the necessary realism for both ground and air Volcano systems.(Carroll 2000) Adapting mounting kits are being fielded in FY'01 for the FMTV 5-ton. Work is currently underway to fit Volcano systems to various smaller rolling stock.(US Army Engineer Branch School 2001)

Two additional ground versions of the Volcano system are currently being developed. First is the Volcano-light, which is a derivative of the original Volcano but has been adapted to the HMMWV. A Single Volcano half rack has a capacity for 20 canisters (120 AT mines or 300 AR mines). Volcano-light will be able to fire from five positions (each side, rear, and intermediate angles). It is intended to give light forces additional capabilities. Operation of the Volcano-light is similar to that of the standard Volcano system. However, due to the diminished canister capacity, Volcano-light will only be capable of laying a 277 x 35 m minefield without reloading once.

Figure 16: Volcano-light (JCF-AWE 1999)

A downsized volcano system is planned primarily for use by the IBCT. Trailer-Mounted Volcano will utilize a MICLIC M200A1 trailer with two racks (40 canisters per

rack) and will be towed by an Engineer Squad Vehicle (ESV). This version is still in the design stage. The intent is to field three per IBCT and three per Combat Engineer Companies in the Interim Division.

Figure 17: Trailer mounted volcano (US Army Engineer Branch School 2001)

4.5 AIR LAUNCHED

Aerial emplacement of sensors can rapidly establish a sensor network over a large area. Disadvantages of air implant operations include detection and interdiction by the enemy air defense system, inaccuracies in emplacement inherent in the air drop technique, and the limited sensor types available for airdrop. Aerial emplacement should be used in areas of low or no air defense threat when the requirement for speed and depth in establishing the sensor network outweighs the need for accurate emplacement and use of confirming sensor types.

4.5.1 Air Volcano

The air Volcano, the "sister" system of the ground Volcano system addressed above, is the fastest method for emplacing large tactical minefields. It provides a three-dimensional capability that allows units to emplace minefields in deep, close, and rear operations. Although mine placement is not as precise as it is with ground systems, air

Volcano minefields can be placed accurately enough to avoid the danger inherent in minefields delivered by artillery or jet aircraft.

The air Volcano multiple-delivery mine system is dispensed from a UH-60A Blackhawk helicopter. Its configuration is the same as the ground Volcano system except the mounting hardware for the UH-60A Blackhawk includes a jettison subassembly used to propel the Volcano racks and canisters away from the aircraft. Mines are dispensed from their canisters by an explosive propelling charge, 35 to 70 meters from the aircraft's line of flight. The aircraft flies at a minimum altitude of 1.5 meters, at speeds of 20 to 120 knots. It can deliver up to 960 mines per sortie.

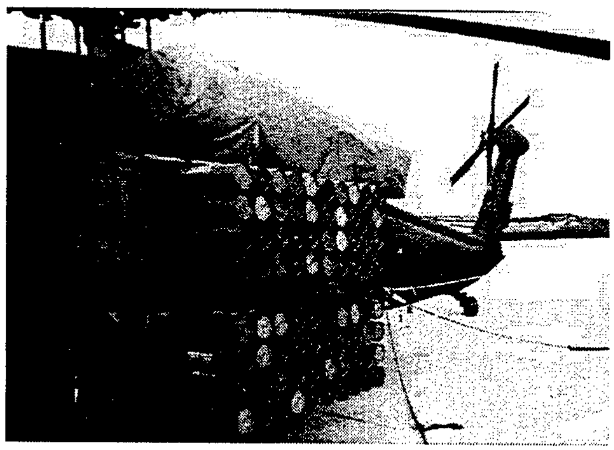


Figure 18: M139 Volcano system with training mines (Geocities 2000)

The air Volcano system has three distinct limitations. First, it takes three to four hours alone to install the air Volcano system on a UH-60A Blackhawk. Second, the total weight of the air Volcano system is 2,886 kilograms. An aircraft will be close to its maximum gross weight when it contains the Volcano system and a full crew. Based on weather and environmental conditions, the aircraft may be required to execute the mission without a full fuel load, thus reducing enroute time. Third, the flight crew cannot operate the M60D machine gun when the air Volcano system is in place.

Several special considerations must be taken into account when considering requesting the air Volcano system support. First, planners must allow sufficient prep time. Dispenser installation takes 4-12 hours, depending on the level of crew training,

plus additional time for load/reload time must be allotted. Second, for purposes of time/distance analysis, asset travel time must include time for aircraft "ramp up" or precombat checks (15-25 minutes). Third, suppression of enemy air defenses (SEAD) must be planned and coordinated before aircraft are committed. Lastly, attack helicopter support must be coordinated; air Volcano aircraft will not take off without helicopter protection.

4.5.2 Gator

The FASCAM system called the Gator has the longest range of any other Scatmine system. It provides a means to rapidly emplace minefield anywhere that can be reached by tactical aircraft. As an aircraft-delivered munition, the Gator is a corps asset. The mines are contained inside tactical munition dispensers (TMDs) that are attached under the wings of high-performance, fixed-wing aircraft. The TMD is a USAF dispenser that was designed for common use with cluster munitions. The primary limitations of the Gator are the availability of high-performance aircraft to emplace the mines and the communications issues with a joint US Army-USAF operation.

The Gator is produced in two versions: the USAF CBU-89/B system and the USN CBU-78/B system. The USAF version contains 94 mines (72 AT and 22 AP) per dispenser and the USN version has 60 mines (45 AT and 15 AP). The Gator is compatible with the USAF A-10, F-4, F-15, F-16, B-1, and B52 aircraft and with the USN A-6, A-7, F-4, FA-18, and AV-8B aircraft.

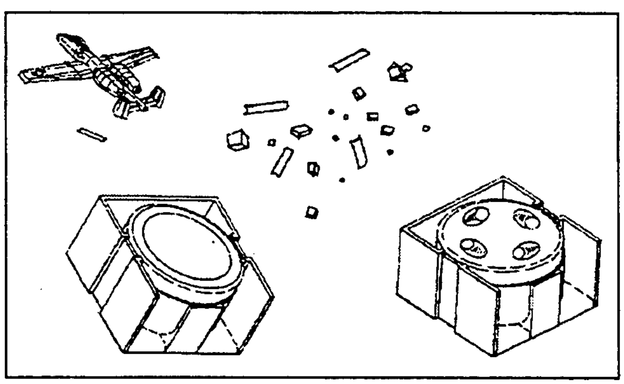


Figure 19: Gator (Commandant US Army Engineer School 1998)

The TMD is released in the air and allowed to fall free. Four linear charges along the edge of the TMD cut the outer casing, and the mines are aerodynamically dispersed. The maximum delivery speed is 800 knots at altitudes of 75 to 1,500 meters. The area of minefield coverage depends on the number of munitions carried, the aircraft speed and altitude, and the altitude where the fuse functions and opens the dispenser. The average area covered is approximately 200 by 650 meters.

4.5.3 TUAV

The Tactical Unmanned Aerial Vehicle comes in many shapes and sizes depending on its intended mission. Currently there are many government sponsored projects, such as the Outrider, Hunter/Pioneer, and the Predator, in the concept stages of development.

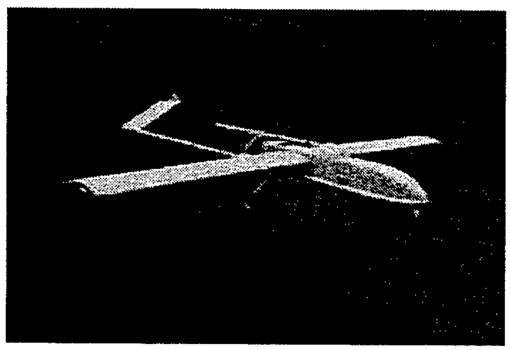


Figure 20: TUAV (Defense Daily Network 2001)

Current plans are for the TUAV to be a part of the RSTA Squadron. They are expected to contribute to situational awareness by providing dedicated aerial reconnaissance. Planned operational requirements call for two TUAVs in the air for 18 hours a day for a three day period. Its operational highlights include its ability to provide real time video imagery to specific locations and assistance in battle damage assessment.

CHAPTER 5 THE "WHO" POSSIBILITIES

5.1 GENERAL

The most observable benchmark in the Army's Transformation will be fielding of the first Initial Brigade Combat Teams (IBCT) at Fort Lewis, Washington, no later than December 2001. These brigades and the interim brigades that follow will be a bridge to the future objective force.

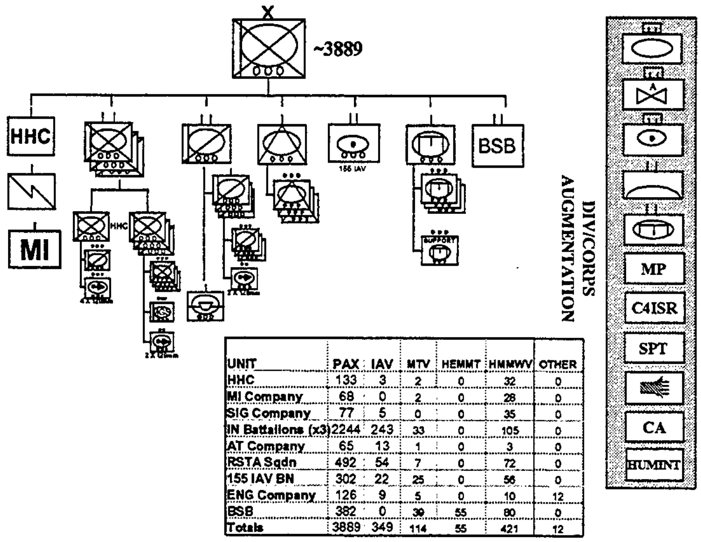
The Objective Force will potentially be fielded starting as soon as 2010. The Army will assess, in about 2003, whether science and technology will enable us to equip the objective force with a "family" of common platforms that we call the Future Combat System (FCS). It is believed that foreseeable future technology breakthroughs will allow researchers to develop this platform into a faster, more sustainable, and more lethal fighting force. Perhaps most important, the intent is for the force to be lighter and highly deployable, allowing for greater flexibility in future assigned missions. The FCS, its variants and configurations, will be the backbone of the objective force.

5.2 IBCT

The IBCT has been designed as a full spectrum, early entry combat force. The brigade has utility, confirmed through extensive analysis, in all operational environments against all projected future threats, but it is optimized primarily for employment in small scale contingencies (SSC) in complex and urban terrain, confronting low-end and mid-range threats that may employ both conventional and asymmetric capabilities.

Although its organization resembles that of a separate brigade, the IBCT is a divisional brigade that will normally fight as the first-to-deploy brigade under a division headquarters. Pre-configured in ready-to-fight combined arms packages, the entire IBCT is intended to deploy within 96 hours of "first aircraft wheels up" and begin operations immediately upon arrival at the aerial port of debarkation (APOD).

Interim Brigade Combat Team



UNIT	PAX	IAV	MTV	HEMMT	HMMWV	OTHER
HHC	133	3	2	0	32	0
MI Company	68	0	2	0	28	0
SIG Company	77	5	0	0	35	0
IN Battalions (x3)	2244	243	33	0	105	0
AT Company	65	13	1	0	3	0
RSTA Sqdn	492	54	7	0	72	0
155 IAV BN	302	22	25	0	56	0
ENG Company	126	9	5	0	10	12
BSB	382	0	39	55	80	0
Totals	3889	349	114	55	421	12

Figure 21: IBCT Proposed Organization (Commandant US Army Armor School 2000)

The major fighting components of the IBCT are three motorized, combined arms infantry battalions, supported by additional organic combat, combat support, and combat service support organizations, described further below. Units will be equipped to the maximum extent possible from commercial-off-the-shelf (COTS) and government-off-the-shelf (GOTS) equipment to accelerate development and reduce costs. To meet its demanding deployment threshold, the brigade's design capitalizes on the widespread use of common vehicular platforms, including highly-mobile, medium-weight interim armored vehicles (IAV), coupled with the deliberate minimization of the personnel and logistical footprint in theater.

5.3 RSTA SQUADRON

The Brigade's Reconnaissance, Surveillance and Target Acquisition (RSTA) Squadron is designed to give the Brigade Commander high levels of situational understanding throughout the Brigade's battle space. Its O&O describes a unit optimized for multi-dimensional reconnaissance and surveillance operations in small-scale

contingencies operating in complex and urban terrain. In its primary role of reconnaissance and surveillance, the Squadron orients on the area of operations and the threat vice solely on the main body of the friendly force.

Over the years, the Army's doctrine has been based on an operational context that involves making contact, developing the situation, then maneuvering for decisive combat. The RSTA is designed within the Brigade's structure to dominate situational understanding and provide he opportunity for the commander to first develop the situation, maneuver out of contact, then make decisive contact to defeat the enemy at a time and a place of his choosing. The RSTA Squadron is designed to provide high quality information and knowledge concerning the widest array of threat conditions common to small scale contingencies including: conventional and unconventional enemy forces, terrorists, trans-national groups, para-military/police organizations, political groups, organized criminal groups, etc. (Bell 2000)

5.3.1 Organization & Design

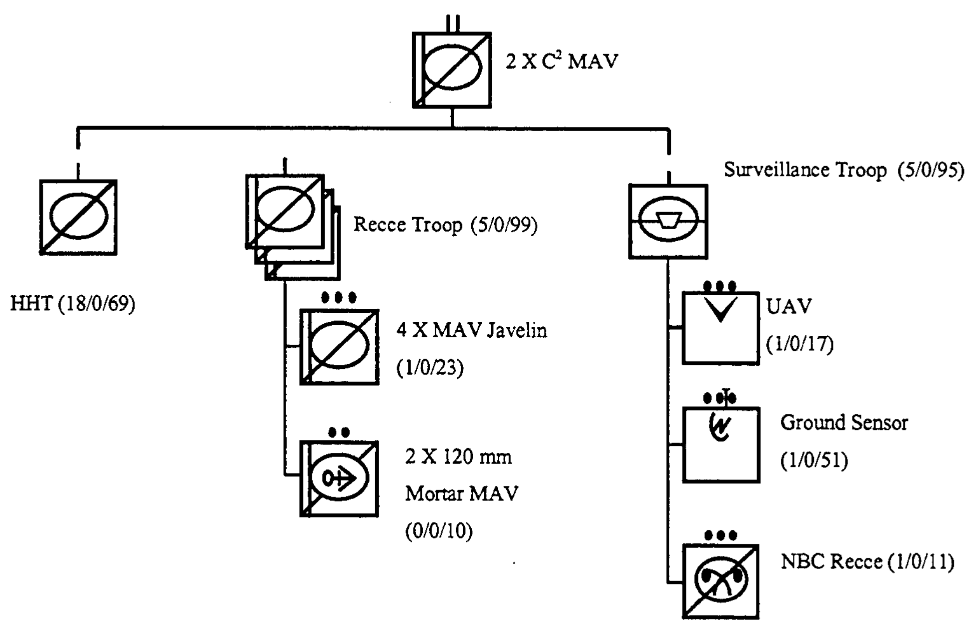


Figure 22: RSTA Squadron Organization (Commandant US Army Armor School 2000)

The Squadron includes a Headquarters Troop, three Reconnaissance Troops, and a Surveillance and Target Acquisition Troop. Appendix E contains more detailed sub-unit diagrams.

The RSTA Squadron is the "eyes and ears" of the IBCT, the primary intelligence collection and information source required by the commander and staff to plan, direct, and assess IBCT operations. It has a unique relationship to the other maneuver units in the Brigade. While the Infantry Battalions are assigned areas, zones or sectors of operations, the RSTA Squadron must be capable of operating throughout the entire Brigade area of responsibility, including those areas assigned to the Infantry and other Brigade units. The RSTA Squadron's employment will be based on mission analysis and will not be uniformly applied in every operation; essentially an expanded type of multi-dimensional area reconnaissance. (Commandant US Army Armor School 2000)

5.3.2 Recce Troops (3)

Each of the three Reconnaissance Troops includes a troop headquarters, three reconnaissance platoons and a mobile mortar section. Reconnaissance platoons are organized with four reconnaissance vehicles and crews and a scout section for dismounted reconnaissance. Dismounted squads will be equipped with Javelins in a close-in defense against armored threats. Dismounted squads would only emplace and utilize the Javelins when scout assets become inadvertently engaged with superior armored forces. A Mortar section consisting of two mobile mortars and a fire direction center complete the troop design.

5.3.3 Surveillance and Target Acquisition Troop

The Surveillance and Target Acquisition Troop provides the Squadron Commander a mix of specialized capabilities built around airborne and ground mobile sensors. They will be required to operate throughout the Brigade Area of Responsibility from 50 x 50 km up to 100 x 100 km. The UAV platoon launches, flies, recovers and maintains the RSTA Squadron's four aerial reconnaissance platforms. The Ground

Sensor Platoon consists of ground based radio signals intercept and direction finding teams capable of conducting nodal and pattern analysis of area communications activities. The Ground Sensor Platoon also provides remotely emplaced acoustics monitoring capabilities that capture sophisticated threat personnel and equipment measurements and signatures. In addition, the platoon employs GSRs to monitor vehicle and personnel traffic. The Ground Surveillance Platoon also has a dedicated communications terminal that transmits, reports and receives voice, data, digital and imagery from sources through national level. (Commandant US Army Armor School 2000)

CHAPTER 6 MODEL FRAMEWORK METHODOLOGY

6.1 GENERAL

The next step in this sensor research project is to develop the framework for a potential optimization model. Models are determined by literature research, survey, brainstorming, formulation and evaluation. The steps in the model methodology are to

1) determine goals and sub-goals,
2) determine appropriate metrics,
3) determine capabilities and consequences,
4) determine most critical metrics for the system, and
5) determine how to implement the metrics (LP, IP, or MIP?)

The three fundamental concerns in forming an operations research model are 1) the decisions open to the decision makers, 2) the objectives making some decisions preferred to others, and 3) the constraints limiting decision choices, and Since this research primarily focuses on the "who" and "how" elements of networked sensor technology, it is initially viewed as a potential combined network and assignment problem, which lends it towards an integer programming configuration. Modifications will be made as the model develops. Figure 23 below outlines the proposed determination sequence for this potential optimization model.

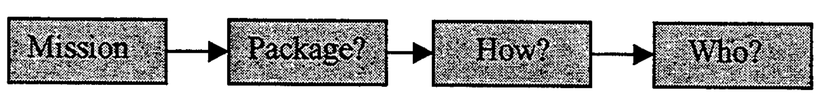


Figure 23: Basic model framework

6.2 GOALS OF NETWORKED SENSORS

Many applications, especially those in the public sector, must simply be treated as multi-objective. When goals cannot be reduced to a common scale of cost or benefit, trade-offs have to be addressed. Although intricate, analysis will almost certainly become more challenging. Multi-objective models of complex problems assume that we always want more of everything – lower values of objectives being minimized at the same time as high values of criteria being maximized. Emphasis is on efficient solutions, which are optimal in a certain multi-objective sense.

With respect to networked sensors, tactical commanders desire many goals to be met. These goals in operations research terms are also known as objective functions. A leader determines which goals are more important to a given mission and therefore reorders or weights the specific goals differently. Thinking tactically, a commander would want probably want the sensor network to be in place for a certain length of time in order to complete a given mission. Obtaining key information without enemy detection would be two other primary goals. Table 1 below outlines suggested primary goals for network sensor planning.

Objective	Definition	Dimension/Scale
MAX Op Time	Extend expected sensor operational time	Minutes, 1 to ∞
MAX SA	Gain situational awareness	Subjective based on sensor accuracy data, 1-10
MAX Stealth	Reduce detectability	Subjective, 1-10

Table 1: Multiple objective functions

Goal programming is a common technique for handling multiple objective functions. It is the most popular approach to dealing with multi-objective optimization problems because it reduces complex multi-objective tradeoffs to a standard, single-objective mathematical program in a way that decision makers often find intuitive. This alternative is constructed in terms of target levels to be achieved rather than quantities to

be maximized or minimized. Goal levels specify the values of the criteria functions in an optimization model that decision makers consider sufficient or satisfactory. It is probably more realistic to assume that the importance of any criterion diminishes once a target level has been achieved.

The first goal of any private business is to maximize profit. Since the actual costs of the sensors should be viewed as sunk costs for purposes of this analysis, the next ideal goal would be to minimize operational costs.

Since this technology is still in the developmental stage, the following figures are a very basic estimate of potential sunk costs associated with networked ground sensors:

UGS cost in quantities = ~ \$200 / sensor

UGS (Wide area surveillance/coverage) = 9600

20 x 40 km field (400m detection range vs. TEL)

MAV cost in quantities = ~ \$5000/ MAV

MAVs (Wide area surveillance/coverage) = 32

20 x 40 km field (2.5 km radius of action) (Lockheed Martin 1999)

Other key goals could include quick emplacement capability, sensor durability, and fast sensor to network to operator transmissions. Table 2 below outlines suggested subgoals for network sensor planning.

Objective	Definition	Dimension/Scale
MIN Cost	Reduce operational costs, measured in battery life/power consumption	\$/battery, estimate with expected life probabilities, 1 to ∞
MAX Mobility	How to emplace the sensor network the fastest	Minutes, 1 to ∞
MAX Sustainability/ Survivability	Durability of sensors themselves	Subjective based on sensor life expectancy rates, 1-10
MIN Combat Assessment/ Warning	Time it takes to receive sensor transmissions and evaluate them	Subjective based on evaluation of data time stats, 1- 10

Table 2: Additional multiple objective functions (Subgoals)

6.3 TECHNICAL CHALLENGES

Combining technology and tactical realities always poses challenges. The list below highlights many of the issues that must be taken into account when planning for network sensor use.

- Low power signal processing
- Fusion of multiple sensors
- Low power networking
- Long-haul communications
- Remote deployment
- Increased maintenance requirements
- Increased operator training requirement
- Effect on soldier morale (possible information overload)
- Increased dependence of new technologies

Many of the above technical challenges could be viewed as additional objective functions. More than likely, they will be added to the list of constraints as the desired technical requirements evolve.

6.4 DESIRED OUTPUT COMBINATIONS OR SUBSCRIPTS

Three desired items are to be determined with this model. They are as follows:

- Which "Package" – which networked sensor "package" is qualified for a given mission
- The "How" - which platform is qualified to distribute the available "packages", and
- The "Who" - which part of the IBCT has the necessary platform to fulfill a given mission

6.5 POTENTIAL CONTROL (ENDOGENOUS) VARIABLES

Endogenous variables are those which the operator has some control over. In the tactical sense, these issues are determined by the requirements for a given mission. For this application, the most relevant variables for tactical placement of networked sensors were chosen.

Mission is addressed and would be entered into the model as a common scaled number assigned to a surveillance or defensive posture mission for example. Naturally, location, time, and coverage go hand in hand. For this model, the variables addressed in Table 3 below, are suggested issues to be addressed when modeling networked sensor technology.

Variable	Definition	Dimension/Scale
Mission	Classify by type (i.e. surveillance or defense)	Assign scaled number to a particular mission
Implant location	Where the networked is to be delivered	Use NAIs with assigned numbers
Time	Required time deadline or how many hours until expected enemy activity	Minutes, 1 to ∞
Coverage Time	Time sensors must cover a given area	Minutes, 1 to ∞
Coverage Area	Amount of terrain for required coverage	Square meters, 1 to ∞

Table 3: Endogenous Variables

6.6 POTENTIAL UNCONTROLLABLE (EXOGENOUS) VARIABLES:

Exogenous variables are those in which the operator has limited or no control over. For this kind application, the list of uncontrollable variables could go on and on, but the ones addressed seemed to be the most applicable. The enemy's size and intent are only predicted based on intelligence information. The terrain, weather, and atmospheric effects go hand in hand are certainly unpredictable from minute to minute. The other area addressed is equipment and human malfunctions. Both of these variables would be

modeled as probability distributions based on information gathered during test phases of the sensor development. For this model, the variables addressed in Table 4 below, are the suggested uncontrolled variables to be addressed when modeling networked sensor technology.

Variable	Definition	Dimension/Scale
Opfor Size	Number of expected enemy wheeled or tracked vehicles or number of expected enemy personnel	Vehicles, 1 to ∞ or Personnel, 1 to ∞
Opfor Intent	Expected mission of opposing forces	Assign scaled number to a particular mission
Terrain	Classify by type (i.e. rolling hills or urban environment)	Assign scaled number to a particular type
Weather effects	Classify by type (i.e. sunny or torrential rains or atmospheric effects)	Assign scaled number to a particular type
Daylight	Day or night, amount of illumination available at expected time of implant	Binary, determined by a given threshold of available light
Equipment Malfunction	Chance of equipment malfunction (probability of failure statistics)	Distributive variable
Human Error	Chance of malfunction (probability of failure statistics)	Distributive variable

Table 4: Suggested Exogenous Variables

6.7 POTENTIAL CONSTRAINTS

Main constraints of optimization models specify the restrictions and interations, other than variable type, that limit decision variable values. Since this potential networked sensor model addresses several decisions, the constraints have been broken down according to respective categories below.

6.7.1 Overall constraints

Constraints that apply to the entire model are outlined in Table 5 below.

Constraint	Definition	Limit
Budget	Amount of money ($) allocated	TBD
Threat	Expected mission of opposing forces	Assign scaled number to a particular mission
Reliability	Expected success rates of a particular package	Probability distribution
Composition	Package makeups	Which packages are eligible for which missions
Time	Time between order and emplacement	Minutes, 1 to ∞, available, TBD
Redundancy	Requirements for overlap	TBD
Power	Expected battery life	TBD
Life Cycle	Expected required time of coverage	Minutes, 1 to ∞, TBD

Table 5: Overall Constraints

Costs are an important factor in any model. They are most often modeled as part of an objective function but since many of the cost issues are considered sunk costs in a government project, I chose to use also include budget as a constraint at this early stage of the model development. The list below highlights several post sensor development costs to keep in mind:

- Significant non-recurring and/or recurring costs ($)
- Significant life-cycle personnel costs (i.e. rotation issues)
- Recurring life-cycle costs even without employment (i.e. train-up requirements)
- Force structure – Manning implications

6.7.2 The "Package" constraints

As research continues with sensor technology, actual applications of these sensors should be categorized into mission capable "packages". The Table 6 below outlines potential surveillance missions for networked sensors.

Common Missions/ Monitoring	Required Coverage (m)	Eligible Configurations
Roadway/LOC/Airstrip	500 x 5000	TBD
Intersection	1000 x 1000	TBD
Perimeter Defense	1000 x 1000	TBD
Open Area	500 x 500	TBD

Table 6: Potential Mission Packages

6.7.3 The "How" (Platform) constraints

The available platform for a given mission is dependent on several factors. Table 7 below outlines many of the platform constraints to take into consideration:

Constraint	Definition	Limit
Availability	Number of sensors and associated platforms/infrastructure required	Matrix of availability, TBD
Weight	Weight capacity available for sensor packages on respective platforms	Kg available on respective platforms
Volume	Volume of space required for sensor packages	Cubic meters required of sensor packages
Capacity	Volume of space available for sensor packages on respective platforms	Cubic meters available on respective platforms
Distro	Distribution required (type of mission requirement)	Square meters (i.e. 1x1 or 2x12 km field)

Table 7: Platform Constraints

6.7.4 The "Who" constraints

The available units or personnel for a given mission are dependent on several factors. Table 8 below outlines the mission assignment constraints to take into consideration:

Constraint	Definition	Limit
Personnel	Number personnel available for a given mission	Number of personnel in area of operation
Unit	Implant unit availability for a given mission	Units already committed to other missions

Table 8: "Who" Constraints

CHAPTER 7 MODEL ANALYSIS

The previous chapter charted the framework for a potential optimization model that would, once given a mission, fulfill the following sequence:

1. Determine which "packages" are eligible to complete a given mission
2. Determine which platform can deliver the eligible "packages"
3. Determine which eligible platforms are available for a given mission
4. Determine which unit has the eligible platforms
5. Determine which units with the eligible platforms are available for a given mission

Once more concrete data can be obtained reference the variables and constraints addressed in Chapter 6, a data set would be created. This collection of data would be obtained from various sources currently conducting research related to networked sensors along with many of the offices working the Army Transformation issue.

Once the data set was formed, energy would be directed at the actual model formulation. Since the framework addressed multi-objective functions along with multi-unit constraints, the analysis would be quite complex. Two types of analysis would be initially used to try to evaluate this model - Analytical Hierarchy Process (AHP) and/or Preference Function Modeling (PFM).

CHAPTER 8 CONCLUSION

The Army's transformation places extraordinary demands on sensor technology. The ultimate intended impact of distributed networked sensors is inexpensive and persistent remote surveillance. (Army Research Laboratory 1999) Distributed integrated sensor networks containing autonomous cueing and data management systems will pass information through a series of ground and overhead relay systems to provide pertinent, secure, and instantaneous information and intelligence to tactical commanders.

The current expected duration of the WEBS program is through FY 2003. In the near term, plans include integration of all elements into a WEBS testbed and conducting multiple technology and user field evaluations. Farther term goals include adding more sensor types, adding imaging and non-imaging ATR, and integrating sensors with mobile platforms, such as unattended ground vehicles and small unattended aerial vehicles.

With the model framework this paper suggests, it is hoped that the data gathered through ongoing research can be captured and entered into an optimization model that would greatly assist higher echelon commanders in their decision making processes. It is hoped that current and future research in the WEBS program will contribute greatly to the future combat systems. The intent is for distributed sensors to fill the situational awareness gaps, which ultimately complements global surveillance.

APPENDIX A : ABBREVIATIONS AND ACRONYMS

A

ADAM	Aerial Denial Artillery Munition
AO	Area of Operations
AOI	Area of Interest
AP	Anti-personnel (usually refers to a mine type)
APLA	Anti-Personnel Landmine Alternative Program
APOD	Aerial Port of Debarkation
ARL	Army Research Laboratory
AT	Anti-tank mines (usually refers to a mine type)
AUSA	Association of the United States Army

B

BCT	Brigade Combat Team
BLOS	Beyond Line of Sight
BMS	Battalion Mortar System
BOS	Battlefield Operating Systems

C

C4ISR	Command Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance
CINC	Commander in Chief
CLU	Command Launch Unit
COTS	Commercial Off-The-Shelf

D

DoD	Department of Defense

E

ESV	Engineer Squad Vehicle

F

FASCAM	Family of Scatterable Mines
FCS	Future Combat Systems
FLIR	Forward Looking Infrared
FLOT	Forward Line of Troops

G

GBCS-L	Ground Based Common Sensor-Light
GSR	Ground Surveillance Radar
GOTS	Government Off-The-Shelf

H

HEMTT	Heavy Expanded Mobility Tactical Truck
HUMINT	Human Intelligence

I

IAV	Interim Armored Vehicle
IBCT	Interim Brigade Combat Team
IEWCS	Intelligence & Electronic Warfare Common Sensor
IP	Integer Program
IPB	Intelligence Preparation of the Battlefield
IR	Infrared
IREMBASS	Improved-Remotely Monitored Battlefield Sensor System

L

LOS	Line of Site
LP	Linear Program

M

MASINT	Measurement and Signature Intelligence
METT-TC	Mission, Enemy, Terrain and Weather, Time, Troops Available and Civilians
MIP	Mixed Integer Program
MLRS	Multiple Launch Rocket System
MOPMS	Modular Pack Mine System

N

NATO	North Atlantic Treaty Organization
NVESD	Night Vision and Electronic Sensors Directorate

O

O&O	Organization & Operations
OOTW	Operations Other Than War
ORCEN	Operations Research Center

P

PIR	Priority Intelligence Requirement
PLS	Palletized Load System

R

RAAM	Remote Anti-Armor Mines
RCU	Remote Control Unit
REMBASS	Remotely Monitored Battlefield Sensor System
RF	Radio Frequency
RSTA	Reconnaissance, Surveillance and Target Acquisition

S

SD	Self destruct
SEAD	Suppression of Enemy Air Defenses
SIGINT	Signals Intelligence
SOF	Special Operations Forces
SPLL	Self-Propelled Loader/Launcher (aka MLRS)

SSC	Small Scale Contingencies
SWA	Southwest Asia

T

TMD	Tactical Munitions Dispenser
TRADOC	Training and Doctrine Command
TTP	Tactics, Techniques, and Procedures

U

UAV	Unmanned Aerial Vehicle
UGS	Unattended Ground Sensor
UGV	Unmanned Ground Vehicle
USAF	United States Air Force
USMA	United States Military Academy
USN	United States Navy

W

WAM	Wide Area Munitions
WEBS	Warrior Extended Battlefield Sensor

APPENDIX B : DEFINITIONS

Anti-personnel Land Mine: any munition placed under, on or near the ground or other surface area, delivered by artillery, rocket, mortar, or similar means, or dropped from an aircraft and which is designed, constructed, or adapted to be detonate or exploded by the presence, proximity, or contact of a person

Density: (area vs linear), area = mines per square meter (scatterable minefields), linear = mines per linear meter of frontage (conventional minefields)

Objective Force:

Self destruct (SD) time: limited active life, mines will self destruct after set time has expired (4 hr, 48 hr, 5 day, 15 day)

Scatterable mines (Scatmine): obstacles emplaced without regard to a classical pattern; dispensed remotely by aircraft, artillery, missile, or ground dispenser (Air/Ground Volcano, ADAM/RAAM, Gator, MOPMs)

Situational Obstacle: Obstacle that units plan, and possibly prepare but do not execute unless specific criteria is met

Special Purpose Munition: hand emplaced; used to create expedient obstacles, enhance existing obstacles, or attack specific types of targets (M18A1 Claymore, M93 Hornet)

APPENDIX C : SENSOR SPECIFICATIONS SPREADSHEET

Configurations

Configurations	How	What	# sensors/ set or tube
C1	Hand-emplaced	Seismic/Acoustic set	12
C2		Magnetic Set	12
C3		Passive Infrared Set	12
C4		FLIR Camera Set	3
C5	"MOPM" like	Seismic/Acoustic set	6
C6		Magnetic Set	4
C7		Passive Infrared Set	4
C8	Hornet	Seismic/Acoustic set	6
C9		Magnetic Set	4
C10		Passive Infrared Set	4
C11	155mm Artillery	Seismic/Acoustic set	6
C12		Magnetic Set	4
C13		Passive Infrared Set	4
C14	"Javelin" like	Seismic/Acoustic set	5
C15		Magnetic Set	3
C16		Passive Infrared Set	3
C17	120mm Mortar	Seismic/Acoustic set	5
C18		Magnetic Set	3
C19		Passive Infrared Set	3
C20	MLRS	Seismic/Acoustic set	6
C21		Magnetic Set	4
C22		Passive Infrared Set	4
C23	"Flipper" like	Seismic/Acoustic set	6
C24		Magnetic Set	4
C25		Passive Infrared Set	4
C26	UGV	Seismic/Acoustic set	3
C27		Magnetic Set	2
C28		Passive Infrared Set	2
C29	Ground Volcano	Seismic/Acoustic set	6
C30		Magnetic Set	4
C31		Passive Infrared Set	4
C32	Air Volcano	Seismic/Acoustic set	6
C33		Magnetic Set	4
C34		Passive Infrared Set	4
C35	"Gator" TMD	Seismic/Acoustic set	6
C36		Magnetic Set	4
C37		Passive Infrared Set	4
C38	TUAV	Seismic/Acoustic set	3
C39		Magnetic Set	2
C40		Passive Infrared Set	2
C41		FLIR Camera Set	2

APPENDIX C: Sensor Specifications

	Power (Hz) Range	Maximum Effective Range			Range of Detection (degrees)	Probability of Detection			Probability of Classification			Employment Options			
Type		Pers	Wheel	Track		Pers	Wheel	Track	Pers	Wheel	Track	Hand	Tube	Ground	Air
Acoustic	150	50	250	700	360	0.95	0.95	0.95	0.80	0.80	0.80	X	X	X	X
Seismic		30	250	500	360	0.80	0.80	0.80	0.80	0.80	0.80	X	X	X	X
Magnetic		3	15	25	360	0.90	0.90	0.90	0.00	0.00	0.00				
IR/Passive (camera)		20	50	50	40	0.95	0.98	0.99				X			
FLIR (camera)		800	1100	1100	15	0.90	0.90	0.90	0.70	0.70	0.70	X			

APPENDIX D : PLATFORM SPECIFICATIONS SPREADSHEET

APPENDIX D: Platform Specifications

Platform		Specifications								
		Currently who or proposed?	# people	Max Eff Range (meters)	Cost	Weight	Vol cap avail (Cubic inches)	# mines/ sensors at once	sq. meters covered	time to deploy (min)
Hand emplaced:										
	Manual	FCS/IBCT	various	various				6/person	50x50/ person	45
	Robotic (ARES)	RSTA	1 to 2	100	various	various		3		60
	MOPMS ("suitcase" dispensed)	EN Bde	3 to 4	35				21 per suitcase	semi-circle w/ 35m radius	0.5
	Hornet	SOF	1	100	$60,000				100x100	20
	IREMBASS: Magnetic, seismic/acoustic	SOF & MI BNs	2 to 5			6.5 lbs or 2.95 kgs				
Tube launched:										
	ADAM (155mm SP Howitzer)	FA	driver + 2 man crew	17600			275	36 AP mines per M731 round	200x200	15-30
	RAAM (155mm SP Howitzer)	FA	driver + 2 man crew	17600			275	9 AT mines per M741 round	200x200	15-30
	Javelin/TOW	FCS/Reece soldiers	1	2500				unknown		0.5
	Battalion Mortar System (BMS)	FCS/Reece soldiers	driver + 2 man crew	7200				unknown		
	MLRS	FA	driver + 2 man crew				2300	unknown		

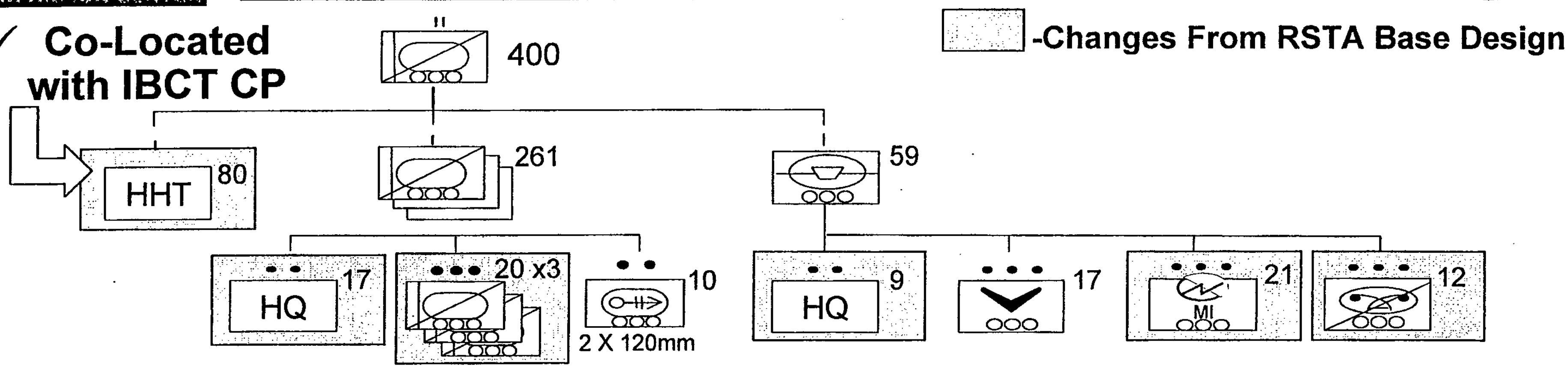
APPENDIX D: Platform Specifications

Vehicle launched:										
	Flipper (via APC, 2 or 5 ton)	EN	driver + 2 man crew	35				unknown	70 X 245	
	UGV	RSTA	1 to 2							
	Volcano ground (via 5ton, HEMTT, or PLS)	EN	driver + 1 man crew				353	6 per canister	120x277	10
Aircraft launched:										
	Volcano air (UH-60A Blackhawk)	EN & AV	1 to 2				353	960	35x1100	10
	Gator (Air Force & Navy versions)	requested Corps asset	1 to 2					94 AP per TMD	200x650	
	TUAV or UAV-R (Unmanned Aerial vehicle - recon)	RSTA	1 to 2				various			20
	GPADS (parafoil concept)		1 to 2							

APPENDIX E : RSTA SQUADRON ORGANIZATIONAL CHARTS

Organization

✓ Co-Located with IBCT CP



Capabilities

- ✓ RSTA Sqdn CDR Acts as CMD GRP/TAC CP Lead
- ✓ RSTA Sqdn CP(-) Performs as Jump CP for IBCT
- ✓ RSTA Sqdn CP(-) Lead for Deployment/RSOI/Security Ops
- ✓ Ground Recon Capability per Sqdn
  - 9 Routes or 18 NAIs
- ✓ Air – Ground – Sensor Team
- ✓ 4 REMBASS / GSR Platforms
- ✓ 3 Prophet Platforms & 4 UAVs
- ✓ 3 NBC Recce Platforms
- ✓ Close, Complex & Urban Terrain

Limitations

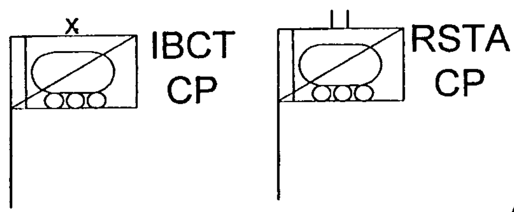
- ✓ Risk is at Section Level – Size of Section for Continuous Operations Risks Fidelity of Operation
- ✓ Local Security, Vehicle Maintenance and Sleep Plans Are Degraded
- ✓ Survivability Degraded By Loss of Ambulance/Crew
- ✓ Reduced S1/S4, S2/ISR and S6
- ✓ Decreased NBC Recce and Prophet Capability

Mitigators

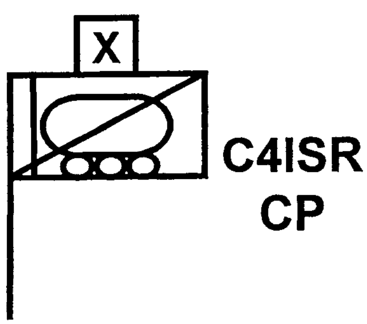
Risk Mitigated with Co-Located HQs:
- ✓ Better Security
- ✓ Buy Back Recce

Organization

✓ Enhances Operational and Cost Effectiveness of Situational Understanding by Integrating the IBCT and RSTA CPs

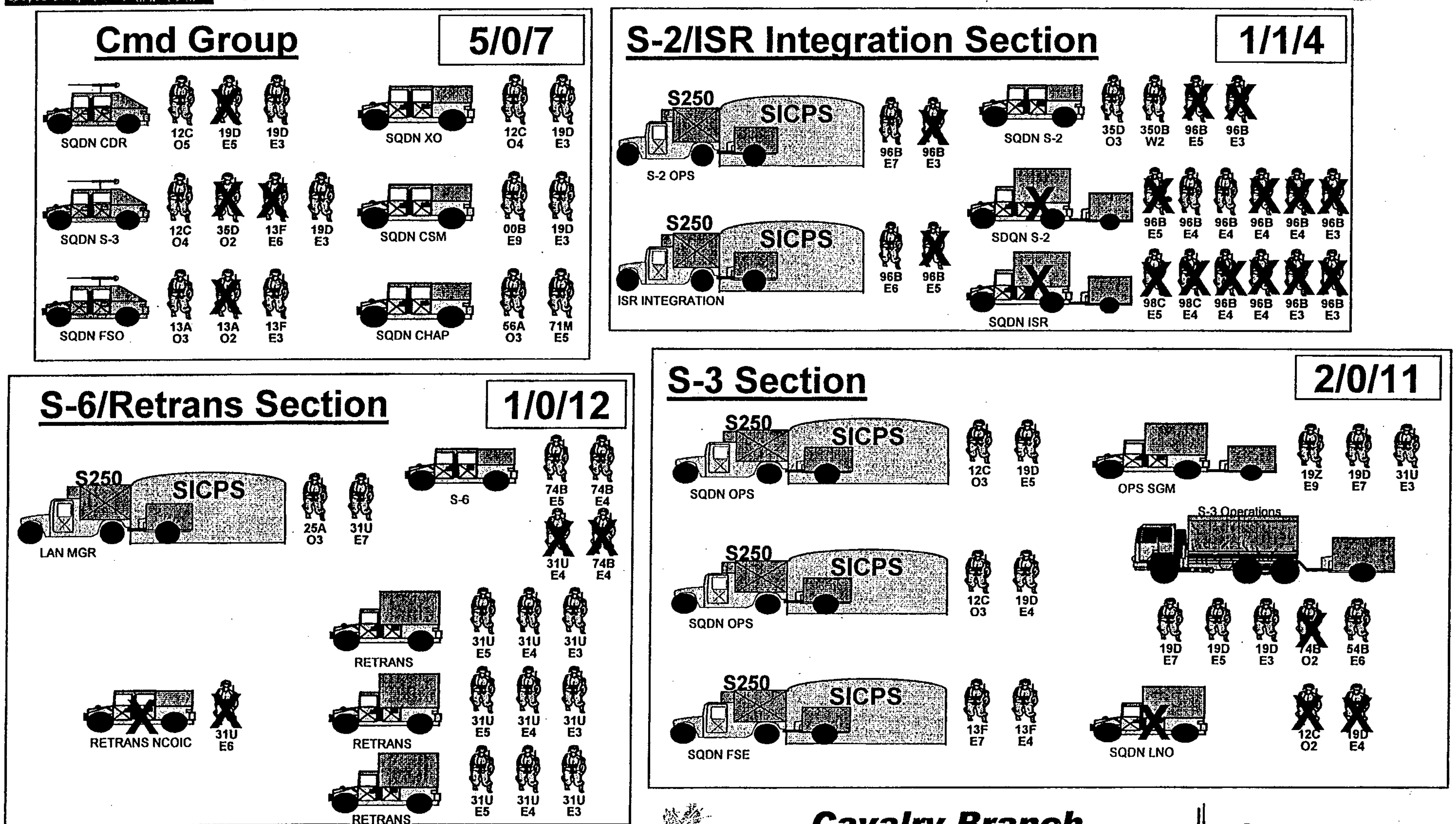


C4ISR CP Design Criteria



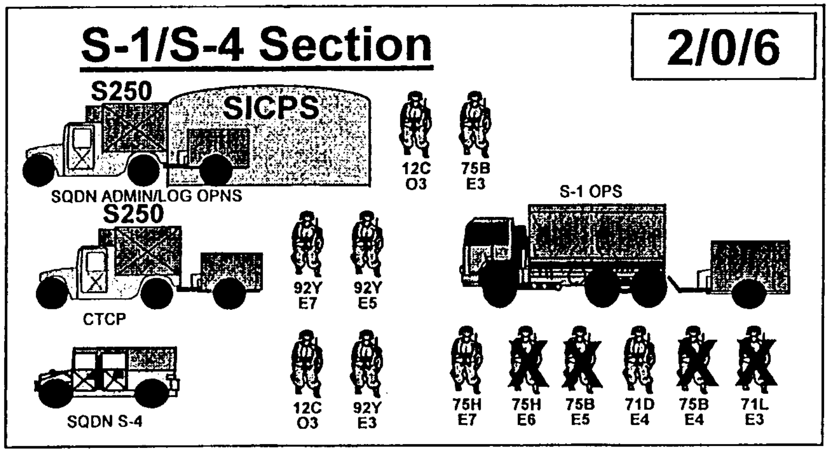
- ✓ RSTA CP Co-Locates With IBCT CP
  - Enables Development of More Timely, Accurate Common Operating Picture
  - Eliminates Redundancies in Information Management, Fusion and Reporting
  - Gain Efficiencies in Associated Battlefield Functions (Fires, Signal, CID, Multi-Dimensional Activities, Civil Affairs, Psyops, CI)
- ✓ RSTA Sqdn CP Must Be Able to Temporarily Disconnect from IBCT CP for:
  - Deployment/RSOI
  - Security Operations
  - Lead Unit in Theater
- ✓ Preserve Air – Ground – Sensor Link Synergy as a Function of RSTA

Assets

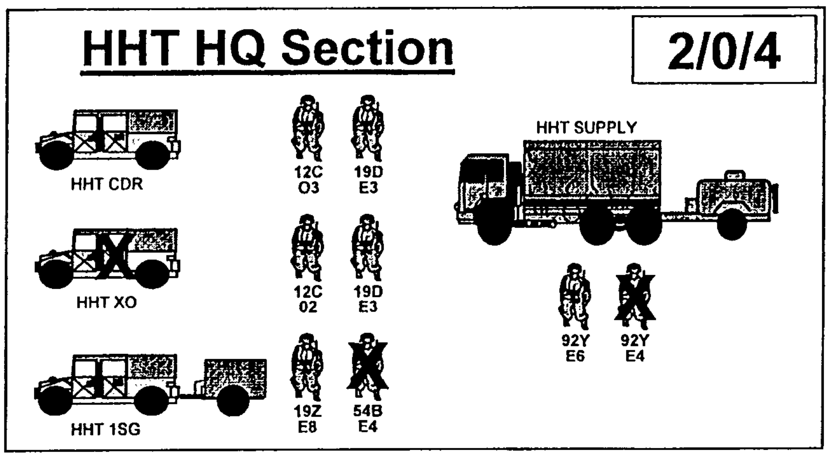


Cavalry Branch,
Doctrine Division, DTDD

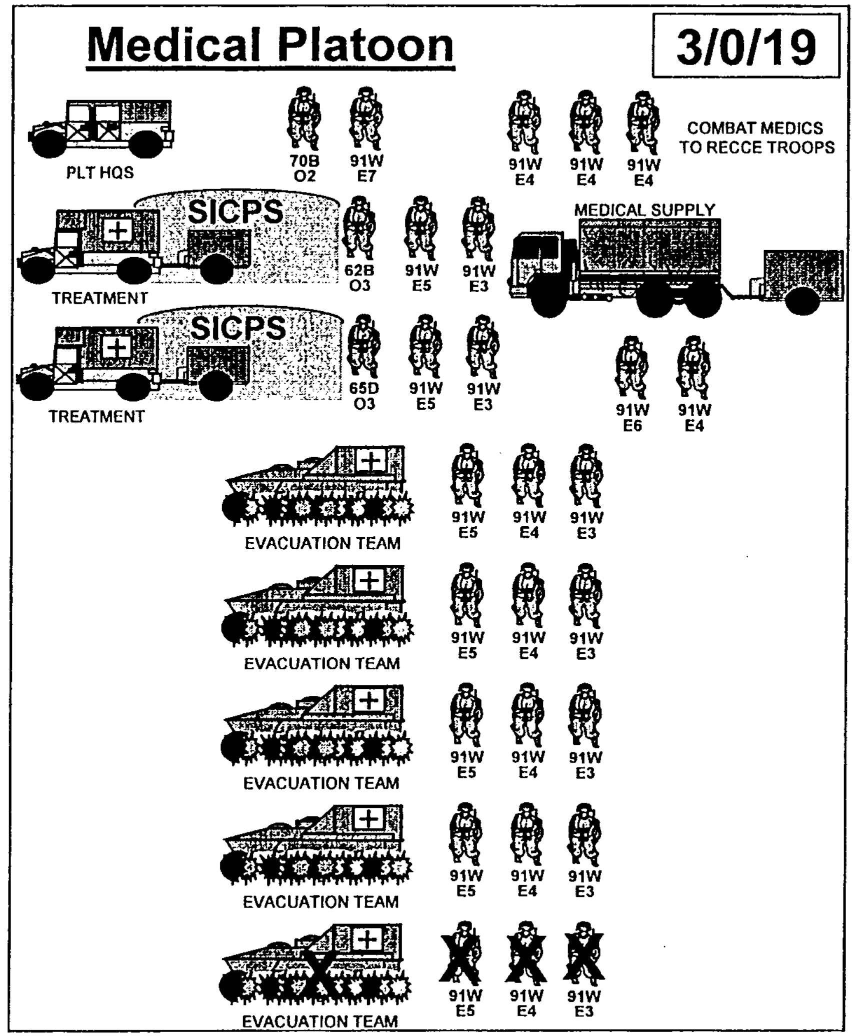
Assets



S-1/S-4 Section
2/0/6
S250
SICPS
SQDN ADMIN/LOG OPNS
S250
CTCP
SQDN S-4
12C O3
75B E3
92Y E7
92Y E5
12C O3
92Y E3
S-1 OPS
75H E7
75H E6
75B E5
71D E4
75B E4
71L E3



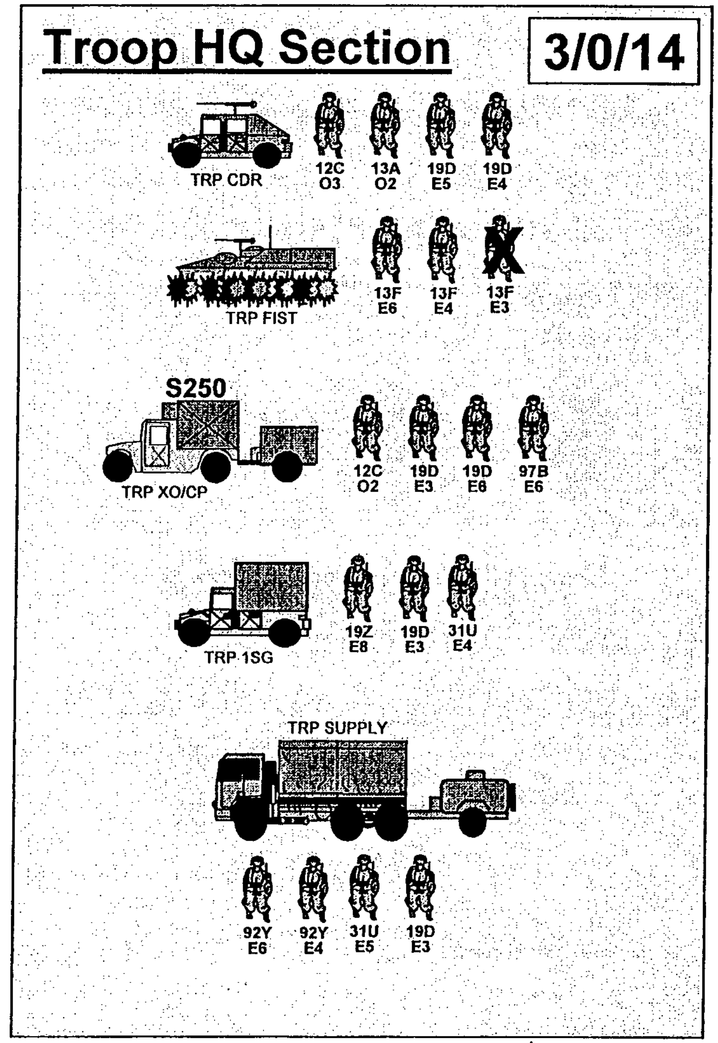
HHT HQ Section
2/0/4
HHT CDR
HHT XO
HHT 1SG
12C O3
19D E3
12C 02
19D E3
19Z E8
54B E4
HHT SUPPLY
92Y E6
92Y E4



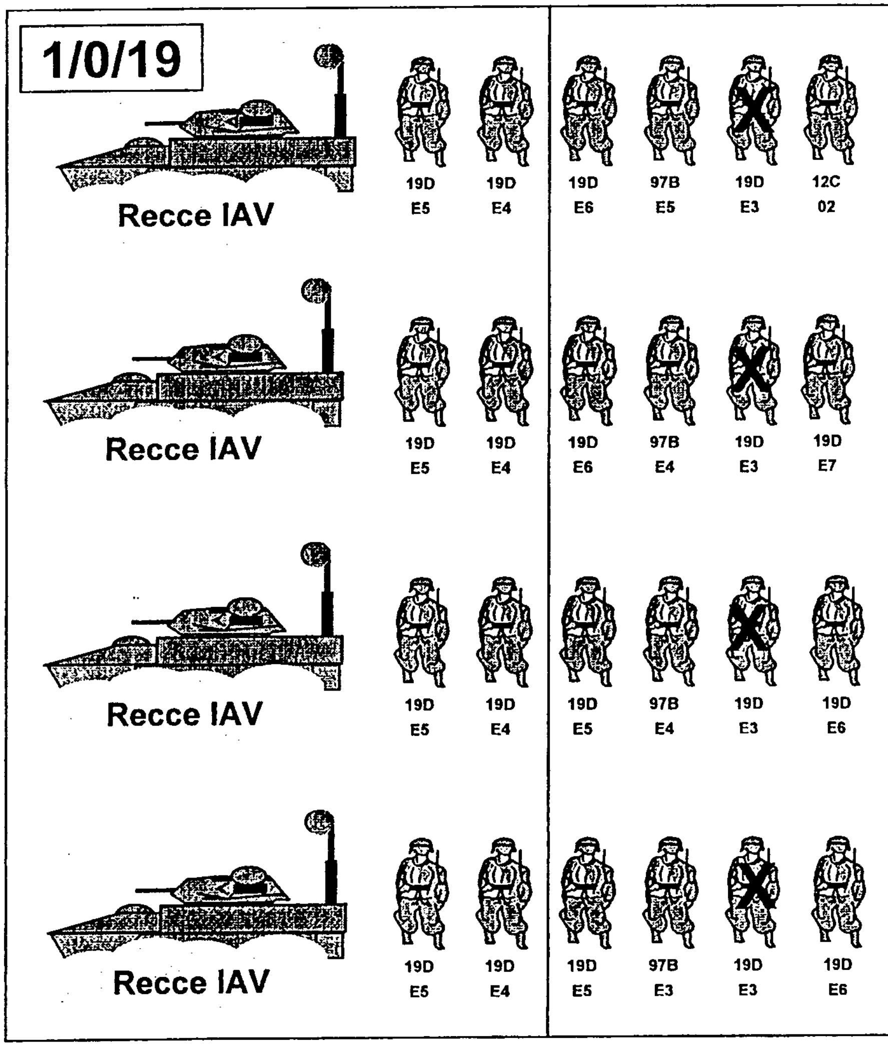
Medical Platoon
3/0/19
PLT HQS
70B O2
91W E7
91W E4
91W E4
91W E4
COMBAT MEDICS TO RECCE TROOPS
SICPS
TREATMENT
62B O3
91W E5
91W E3
MEDICAL SUPPLY
SICPS
TREATMENT
65D O3
91W E5
91W E3
91W E6
91W E4
EVACUATION TEAM
91W E5
91W E4
91W E3
EVACUATION TEAM
91W E5
91W E4
91W E3
EVACUATION TEAM
91W E5
91W E4
91W E3
EVACUATION TEAM
91W E5
91W E4
91W E3
EVACUATION TEAM
91W E5
91W E4
91W E3

Assets

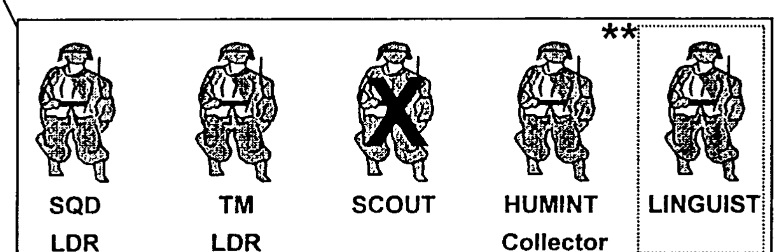
- ✓ Troop HQ Section
  - – Troop CDR/FSO
    - → C2 and Effects
  - – Troop XO
    - → Troop Operations Center
  - – LOG Support
    - → NBC, Commo, Supply



Assets



3 Platoons per Troop
4 Recce IAVs per Platoon
2 Man IAV Crew
3(4) Man Scout Squad per IAV**
--Linguist Augmentation (METT-T)
1 x JAVELIN per IAV



✓Expanded Multi-Dimensional NAI Coverage with Assessment Capability

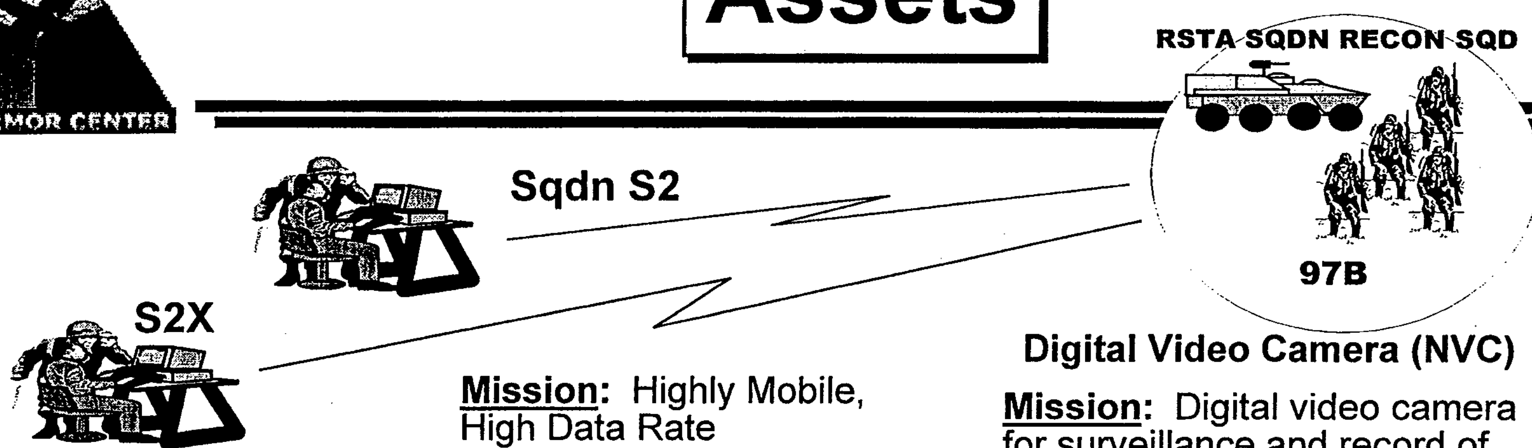
✓Capable of Mounted/ Dismounted Operations

✓HUMINT Collectors

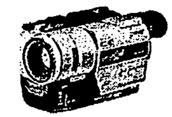
✓Capable of Self-Defense

Cavalry Branch, Doctrine Division, DTDD

Assets



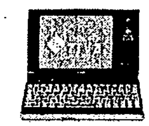
Digital Video Camera (NVC)



Mission: Digital video camera for surveillance and record of interviews.

Mission: Highly Mobile, High Data Rate Communications.

MANET (Mobile Ad-Hoc Network)

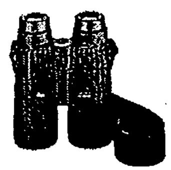


ITRT Prototype

Mission: To Provide HUMINT/CI teams easily portable automation, data transfer, sensor interface, and CHATS functionality.

Multilingual Interview System (MIS)

Mission: Provides means to conduct initial screenings, debriefings and interviews by persons not familiar with foreign languages and sustain languages learned.

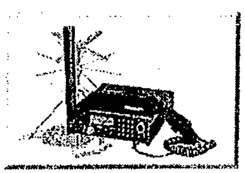


Binos

Mission: Provide stand-off photo capture for viewing of clear, steady images with remarkable detail.

MBITR

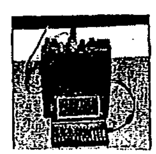
Mission: To provide secure inter and intra team communications over a wide range of user selectable frequencies.



PSC-5

Mission: Tactical Satellite voice and data communications with embedded COMSEC.

PRC-137F

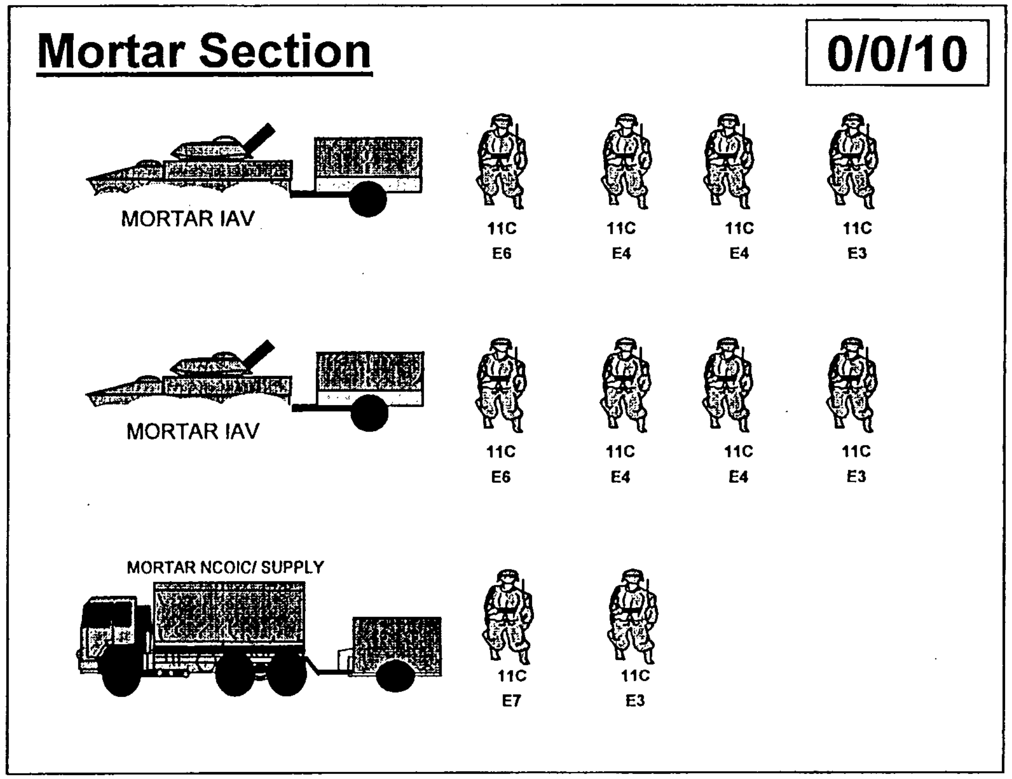


Mission: To serve as a Collector to first base, Mission Support Site, Command Post radio system.

Assets

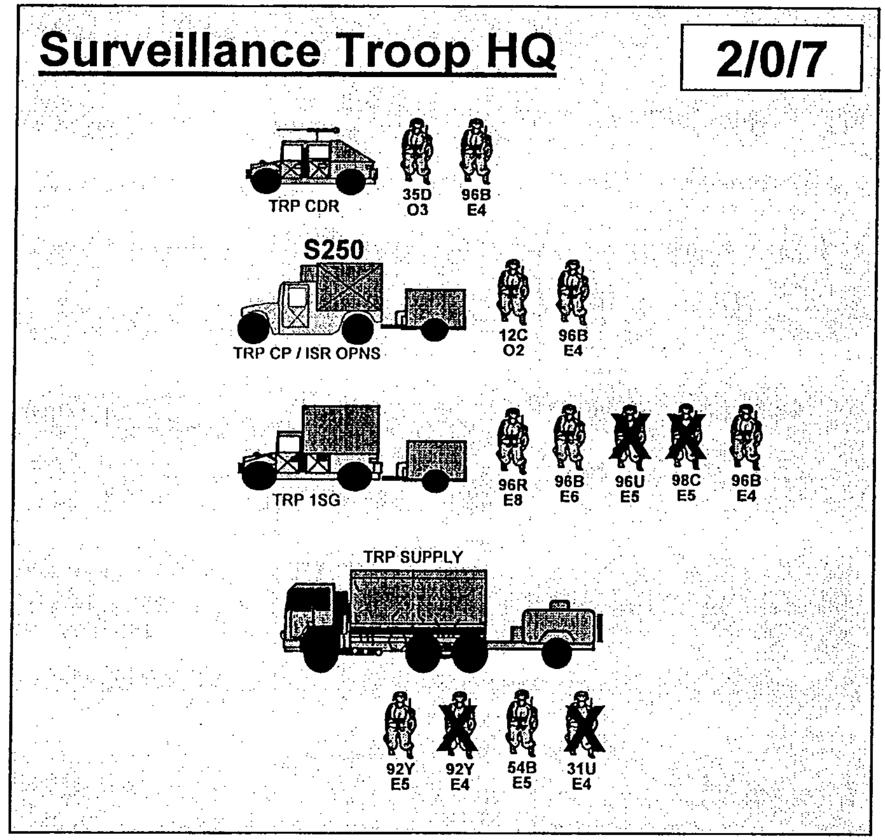
✓ Mortar Section

- 2 x 120 mm Mortars
- Provides Scouts with
  - → Counter Recon Fires
  - → Suppression
  - → Marking
  - → Obscurants
  - → Illumination



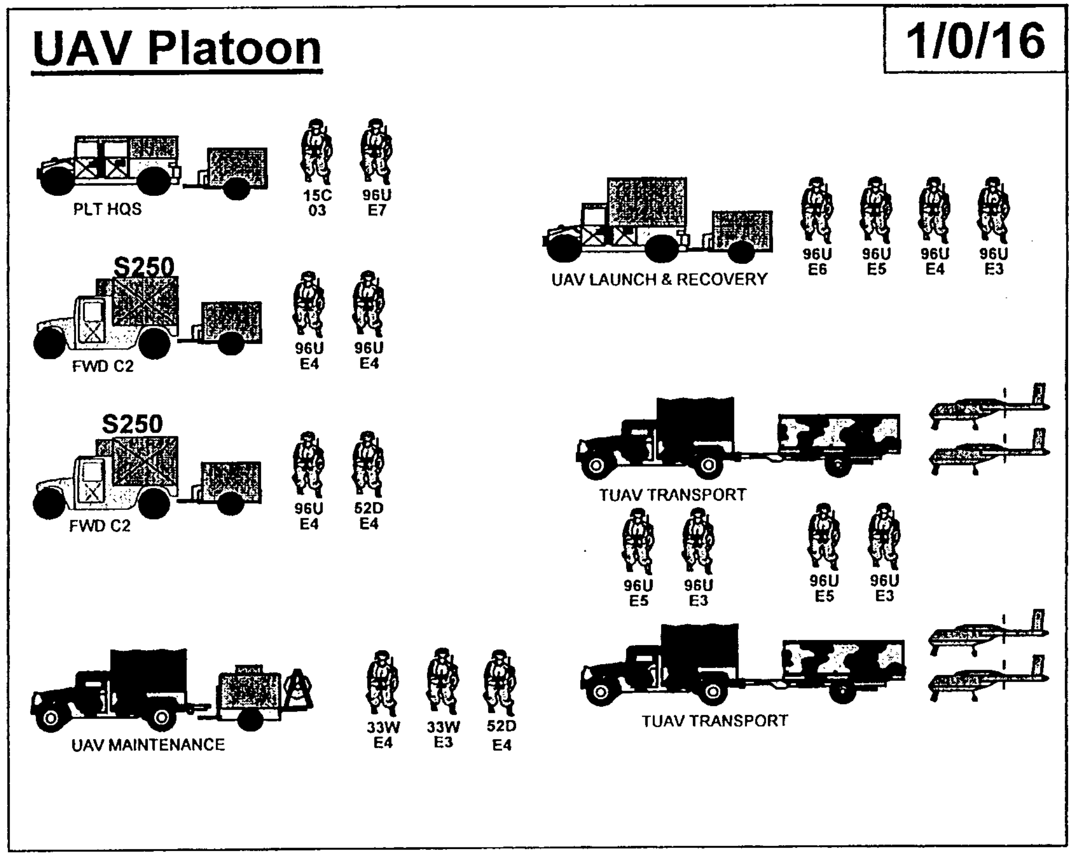
Assets

- ✓ **Surveillance Troop HQ Section**
  - Provides Expanded Surveillance and Target Detection Capability
  - Collection Center for Troop
  - Tactical Employment of Troop Sensor, Reconnaissance and Surveillance Assets

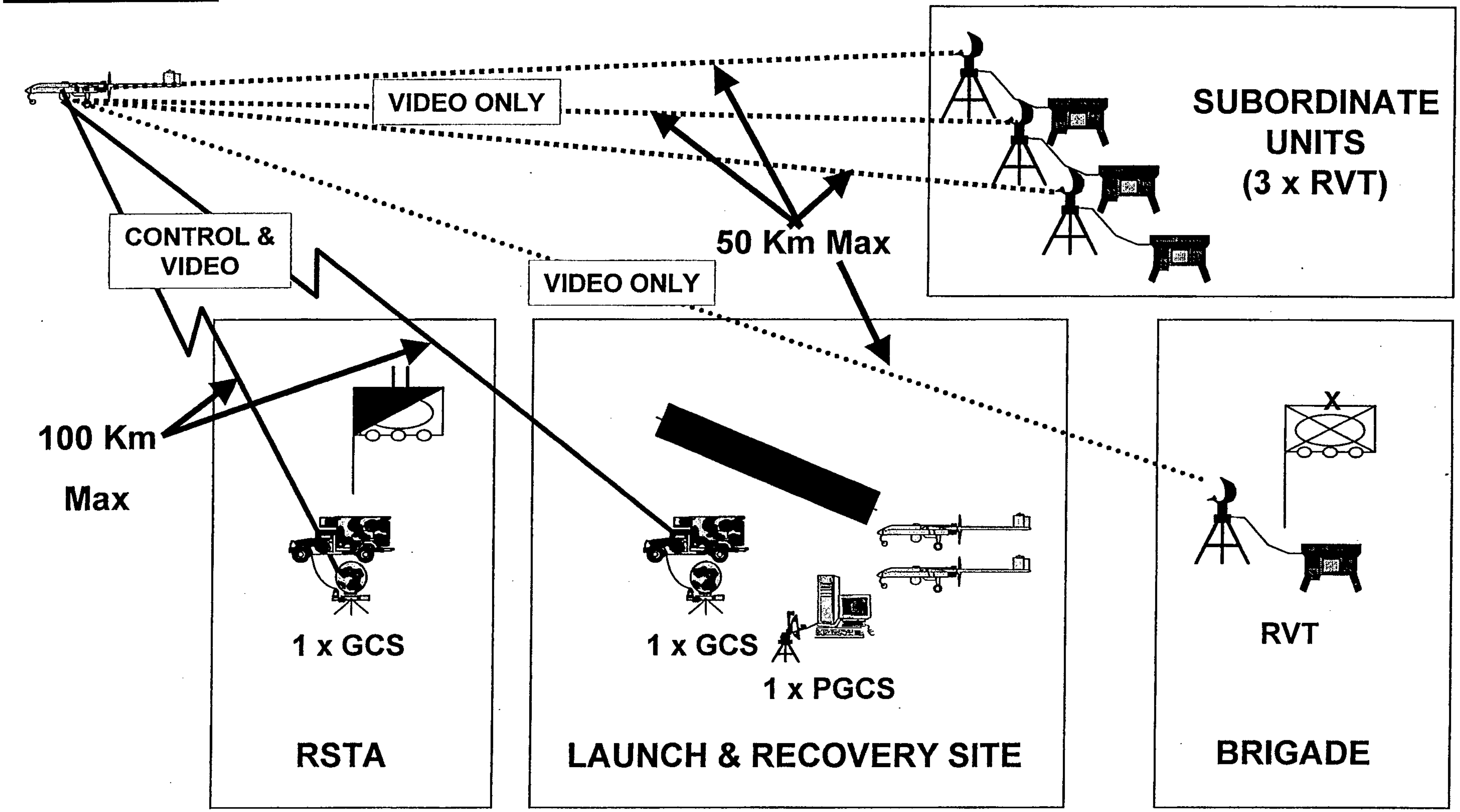


Assets

- ✓ UAV Forward C2
  - Integrates Air Traffic Control for UAV Effort
  - Distributes Information Horizontally/Vertically Across the Battlefield
  - "Air" Complement of the Squadron's Air-Ground Team
- ✓ UAV Recovery & Launch
  - Multiple Sensor Package Capability
  - Organic System Repair Capability



Assets



VIDEO ONLY
CONTROL &
VIDEO
VIDEO ONLY
50 Km Max
100 Km
Max
SUBORDINATE
UNITS
(3 x RVT)
1 x GCS
RSTA
1 x GCS
1 x PGCS
LAUNCH & RECOVERY SITE
RVT
BRIGADE

USA ARMOR CENTER

Assets

DOCTRINE DIVISION

✓ Standard Operations

– Single UAV Flight

– 12/24, 18/24 Surge

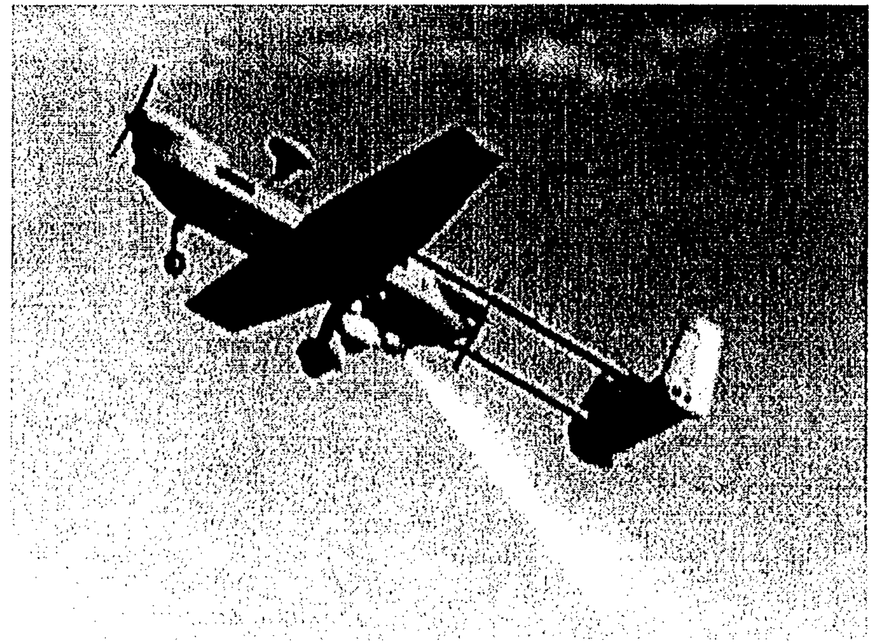
→ Continuous Time on Target

✓ Missions

– 2 UAVs

– Relief on Station

→ No impact; expected and planned



✓ Exceptional Missions

– 2 UAVs

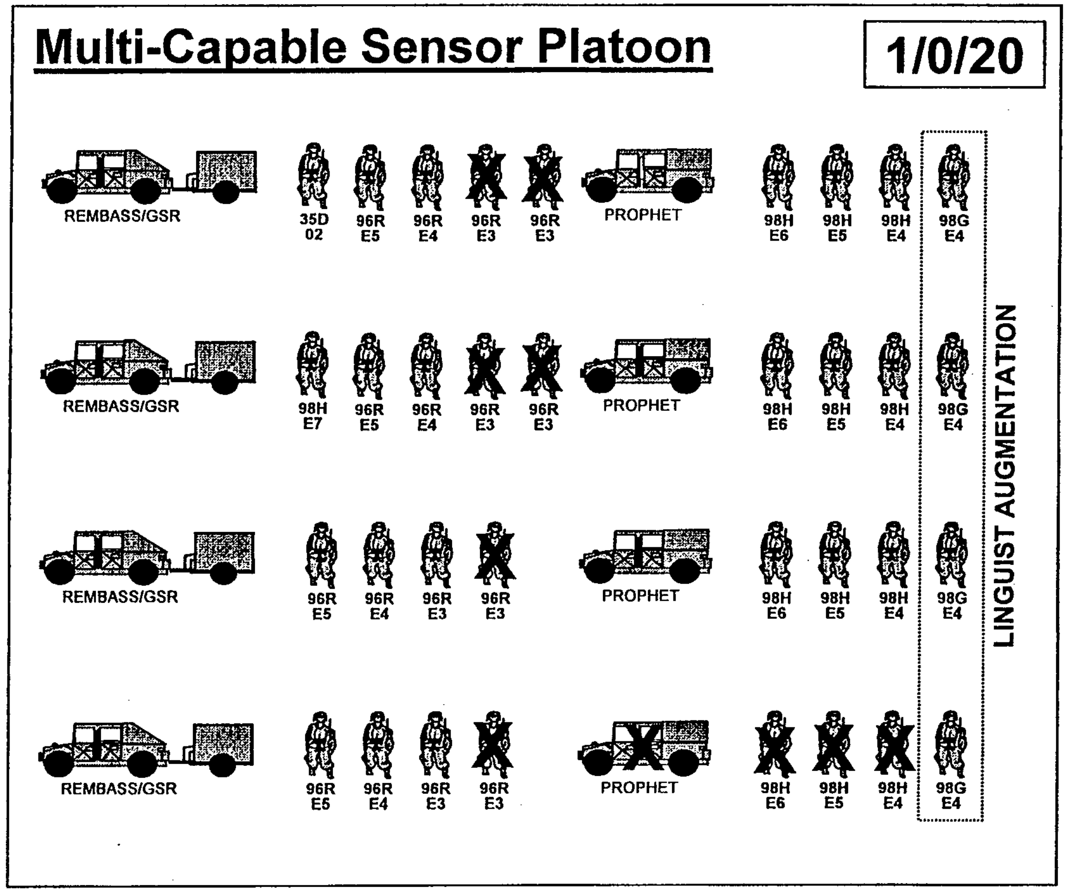
– RSTA

→ RSTA TOC GCS manned for single AV, 12/24 RSTA missions

→ Launch and Recovery GCS manned for minimal tactical operations, with innate restrictions and limitations

Assets

- ✓ REMBASS/GSR Section
  - 4 Sensor Fields
  - 4 PPS-5D GSRs
  - Detect and Classify Both Personnel and Vehicles
  - Remotely Monitored Sensors Responding to
    - →Infra-Red
    - →Acoustic
    - →Seismic
    - →Magnetic Field
- ✓ PROPHET Section
  - 3 Systems
  - Expanded Intercept and DF Capability
  - Future Electronic Warfare and Electronic Attack Functions
  - Linguist Augmentation at Platoon Level



Cavalry Branch,
Doctrine Division, DTDD

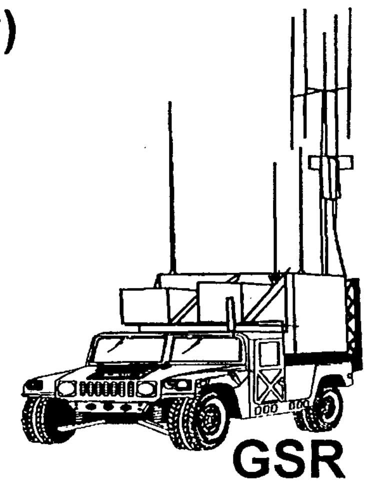
Assets

✓ Classifies targets (moving only)
- Dismounted
- Light vehicle
- Heavy vehicle
- Tracked

✓ Detection Ranges:
- GSR
  - Vehicles- 10,000m
  - Personnel- 6,000m
- REMBASS

REMBASS	Pers	wheel	track
- M	3m	15m	25m
- SA	50m	250m	350m
- IR	20m	50m	

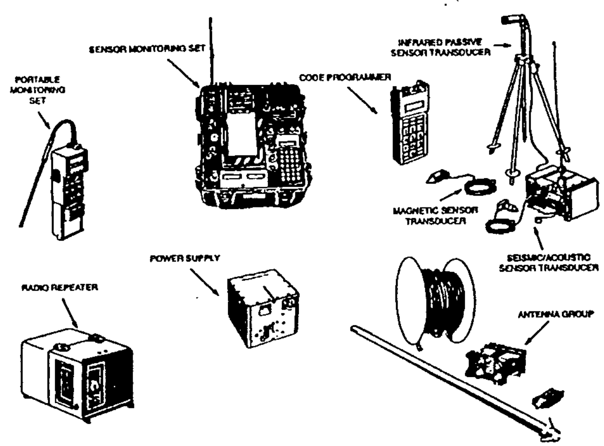
✓ Considerations
- Early warning (360^{O})
- Economy of force
- R & S



Early warning

GSR/REMBASS Provide

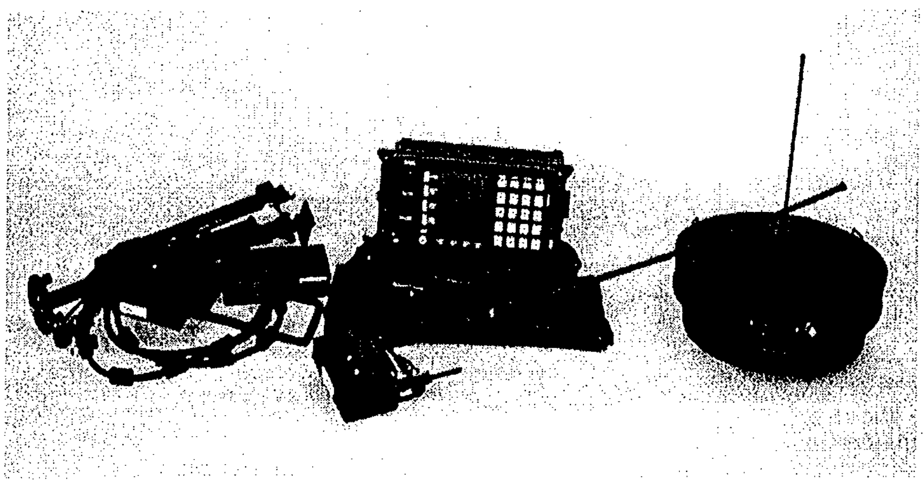
Economy of force

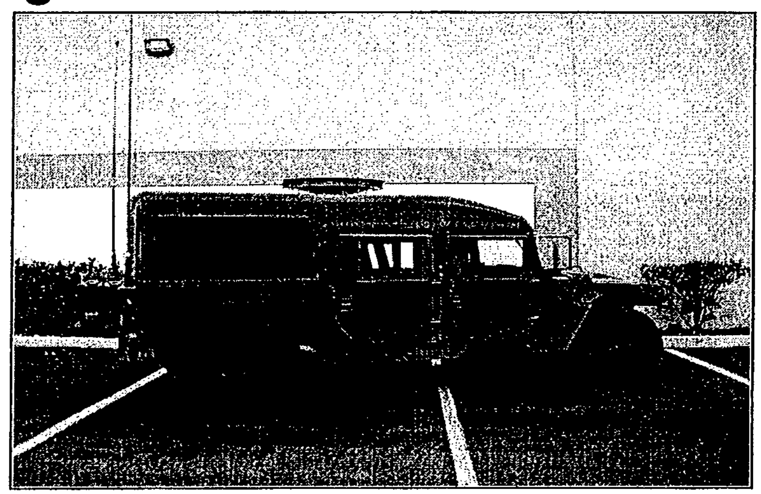


R
E
M
B
A
S
S

Assets

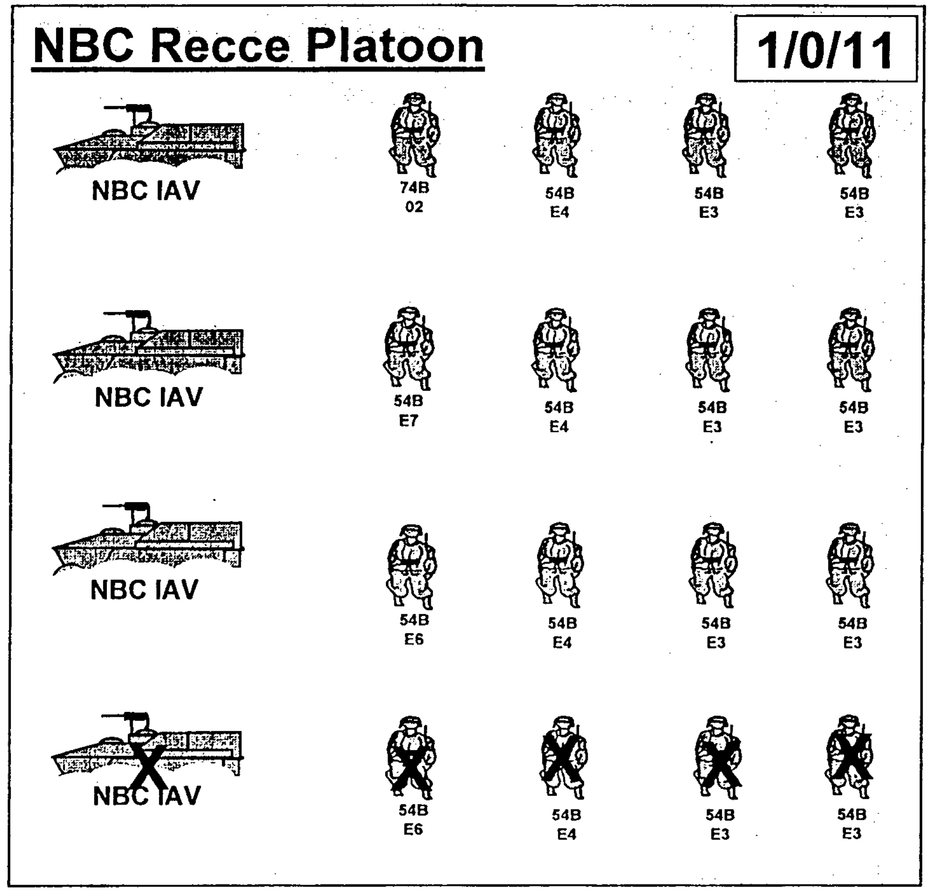
✓ PROPHET Capabilities.
- Stationary and On-The Move Direction Finding
- Dismountable receiver set
- Signals Mapping
- Intercepts / detects signal emitters out to 15 KMs
- Single PROPHET gives Line-of-Bearing
- Multiple PROPHETS give positioning data





Assets

- ✓ NBC Recce Platoon
  - Accounts for WMD by Conducting Predictive IPB for the Brigade
  - Provides Early Warning/Force Protection for the Brigade
  - Conducts Nuclear, Biological and/or Chemical Detection Surveys
  - Surveys Industrial Sites

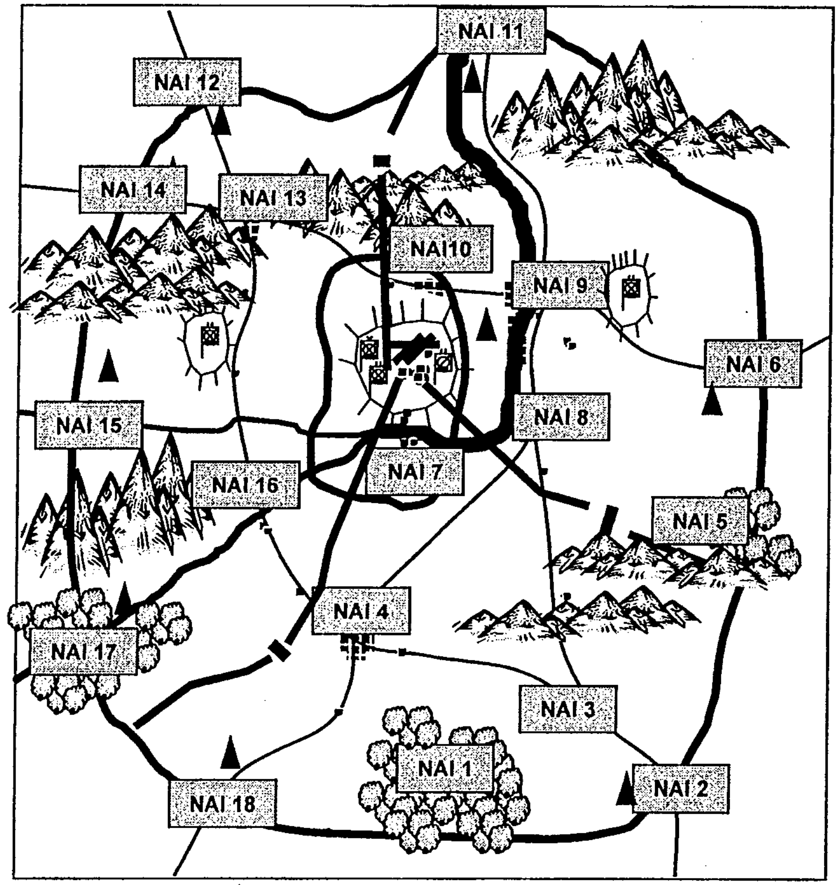


USA ARMOR CENTER

RSTA CAPABILITIES

DOCTRINE DIVISION

- ✓Conducts Reconnaissance and Surveillance (R&S) in Complex, Close and Urban Terrain
- ✓Reconnoiters up to Nine (6) Routes Simultaneously or Conducts Surveillance of up to Eighteen (18) NAIs
- ✓Performs Multi-Dimensional Reconnaissance, Surveillance and Target Acquisition as its Primary Mission



USA ARMOR CENTER

RSTA CAPABILITIES

- ✓Gathers Intel on Conventional and Unconventional Multi-Dimensional Threats
- ✓As Necessary, Gains and Maintains Contact With the Threat
- ✓Sustains R&S Operations Over Extended Areas With Exposed Interior Lines for up to Seventy-Two (72) Hours
- ✓'Sets the Conditions' for the BDE CDR to Attack Multi-Dimensional Threat "Centers of Gravity" on His Own Terms

RSTA CAPABILITIES

- ✓Performs Limited Security Operations, based on METT-TC When Augmented
- ✓Accounts for Weapons of Mass Destruction (WMD) by Conducting Specific WMD IPB for the Brigade
- ✓Reduces Risk to BDE Forces by Assuring Survivability Through "Information As a Catalyst"

USA ARMOR CENTER

RSTA CAPABILITIES

- ✓Shapes the Environment Thru Information and/or Precision Fires to Influence the Threat Commander's Decision Cycle
- ✓Demonstrates Extensive Flexibility and Agility in Planning and Execution
- ✓Establishes Analog and Digital Information Linkages Horizontally and Vertically
- ✓Employs Army or Joint Fires

APPENDIX F: REFERENCES

1. Army Research Laboratory (1999), *"Distributed Microsensing: Devices, Networks and Information Processing,"* Aldelphi, MD, <http://www.arl.army.mil/sedd/index.html>.
2. Army Technology (1999), IREMBASS, 2001, <http://www.army-technology.com/projects /rembass/index.html>.
3. Army Technology (1999), Javelin, 2001, <http://www.army-technology.com/projects /javelin/index.html>.
4. Bell, M. B. B. (2000), *"What's Going On,"* Fort Knox, KY, U.S. Armor Center, <http://www.knox.army.mil>.
5. Carroll, D. (2000). Point Paper: M139 Multiple Delivery Mine System (Volcano). Fort Leonard Wood, MO, US Army Engineer Branch Center, http://www.wood.army.mil>.
6. Cheney, B. (1998). AN/PPS-5 Upgrade Program. 2001, http://www.gordon.army.mil>.
7. Commandant US Army Armor School (2000), Draft FM 34-80-2/ST RSTA Operations, Ft. Knox, KY, Headquarters, Department of the Army, <http://www.knox.army.mil>.
8. Commandant US Army Armor School (2000), IBCT O&O, Fort Knox, KY, Headquarters, Department of the Army, <http://www.knox.army.mil>.
9. Commandant US Army Engineer School (1998), FM 20-32, Mine/Countermine Operations, Ft. Leonard Wood, MO, Headquarters, Department of the Army, <http://www.wood.army.mil>.
10. Commandant US Marine Corps (1997), MCWP 2-15.1, Remote Sensor Operations. Quantico, VA, Headquarters, Department of the Navy, <http://www.quantico.navy.mil>.
11. Defense Daily Network (2001). Tactical Photos, Defense Daily Network. 2001, <http://www.defensedaily.com>.
12. Federation of American Scientists (2000), Ground Based Common Sensor - Light, 2001, <http://www.fas.org>.
13. Federation of American Scientists (2000), M121, 120mm Battalion Mortar System (BMS), 2001, <http://www.fas.org>.
14. Federation of American Scientists (2000), Prophet, 2001, <http://www.fas.org>.
15. Federation of American Scientists (2000), Raptor, 2001,<http://www.fas.org>.
16. Federation of American Scientists (2000), REMBASS & IREMBASS, 2001, <http://www.fas.org>.
17. Geocities (2000), Volcano Platoon, 2001, <http://www.geocities.mil>.
18. Gerber, J. (2001), Sensor Characteristics, Interview, West Point, NY.
19. Hopkins, J. (2001), Warrior Extended Battlespace Sensors (WEBS), Interview, West Point, NY.

20. JCF-AWE (1999), Raptor: Doctrine, Tactics, Techniques, and Procedures (DTTPs), Fort Leonard Wood, MO, US Army Engineer Branch Center, <http://www.wood.army.mil>.
21. JCF-AWE (1999), Volcano-light: Doctrine, Tactics, Techniques, and Procedures (DTTPs), Fort Leonard Wood, MO, US Army Engineer Branch Center, <http://www.wood. army.mil>.
22. Lockheed Martin (1999), *"UGS-MAV"*, <http://www.lockheed.com>.
23. PM Prophet (2000), Prophet, 2001, <http://w4.pica.army.mil>.
24. Shinseki, G. E. (1999), Army Transformation, Washington, DC, <http://www.ausa.org>.
25. Tiboni, F. (2001). "'Smart' WAMS can track, destroy tanks", Army Times. Alexandria, VA.
26. TRADOC (2000). UAV. 2001, <http://www.tradoc.army.mil>.
27. US Army Engineer Branch School (2001), Multiple Delivery Mine System (Volcano), 2001, http://www.wood.army.mil>.
28. US Army Engineer Branch School (2001), Volcano, Trailer Mounted, 2001, <http://www.wood.army.mil>.
29. US Field Artillery School (1999), MLRS, <http://www.sill.army.mil>.